ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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14th March, 1916. D 826

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14th March, 1916. D 830

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STRESSES IN FERRO-CONCRETE ARCHES.

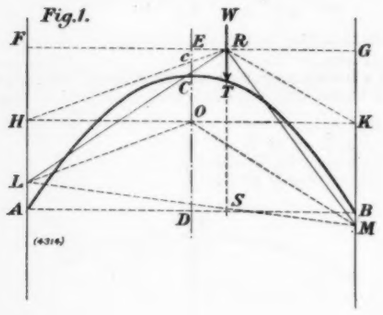
IN *Le Genie Civil*, some little time ago, M. Mesnager, the eminent French civil engineer, gave a remarkably simple method of determining the stresses in ferro-concrete or other rigid arches.

It is based on two assumptions, both generally realisable in practice—viz.:—(1) That the centre line of the arch is parabolic. (2) That the moment of inertia of the cross-section increases between the crown and the abutments according to the law $I \cos\theta = I_0$, where I_0 denotes the moment of inertia of the section at the crown, and θ the inclination of the arch line at the point where the moment of inertia is I. Take, for example, an arch rib of homogeneous material, and of simple rectangular section and of uniform breadth. Then, if the depth at the crown be 12 in., the depth h at any other point would, on this hypothesis, be equal to $\frac{12}{\sqrt[3]{\cos\theta}}$, so that if at the springings θ were 30 deg., the depth would be :—

$$\frac{12}{\sqrt[3]{0.5}} = 15.1 \text{ in.}$$

The plan, therefore, consists in building the arch to a standard type, chosen so as to permit of the whole of the stresses being readily determined by means of a simple graphic construction as follows :—

Fig. 1.



In Fig. 1 let A B C represent the centre line of the arch, and let W denote a load applied at any point of the span. Take C E equal to one-fifth the rise C D, and draw F G horizontally. Take C O equal to one-third C D, and draw H K horizontally. Let R be the point in which the line of action of W cuts F G.

Join R H and R K and from O draw O L and O M parallel to R H and R K respectively. Join R M and R L. Then the intercept between these two lines and the arch gives at every point the bending moment in the arch to the same scale that the triangle L R M represents the bending moment produced by the load on a straight girder simply supported. For example, in the latter case the bending moment directly under the load is represented by R S. To the same scale, the corresponding bending moment on the arch is represented by R T. Similarly, L A represents the bending moment at one abutment and B M that at the other, the two being in this case of opposite sign.

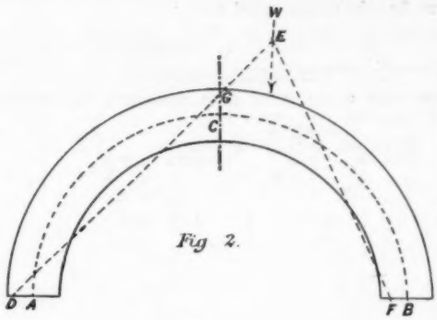
Further, since all parabolic curves are similar, the bending moments produced by a given load will be the same whatever the rise. Hence a single diagram, drawn to a large scale, can be used to find the stresses on every standard arch whatever the rise or span. On the very usual assumption that the work done in compressing the arch-ring is negligible in comparison with that done in bending it, the construction gives rigidly accurate results for the type of arch premised. For a vast proportion of the arches built there seems little objection to the adoption of M. Mesnager's standard form, and the saving in labour will be appreciated by all who have worked out the stresses in a rigid arch by the usual methods.

In view of the great advantages of M. Mesnager's method, a demonstration of its accuracy may be welcomed by some of our readers.

Using the method described in ENGINEERING, February 1, 1895, let A C B, Fig. 2, represent the centre line of an arch-ring loaded by W, as indicated. Assume D E F to be the line of resistance of this load ; then a certain thrust T, say, acts on the arch along the line D E, and another thrust along the line E F. Let G be the point at which the line D E cuts the vertical through C.

Then the action of the left-hand half of the arch on the right-hand half can be replaced by a force T acting in the direction indicated in Fig. 5, whilst the action of the right-hand half on the left hand can be replaced by a numerically equal force acting as indicated in Fig. 3. These forces T may be resolved into their horizontal and vertical components P and S, as shown.

Fig 2.



At a section H J on the right-hand side of the arch the bending moment is obviously :—

$$M = P(a + y) + S x - W z,$$

which, if N be put equal to P a, may be written as :

$$N + P y + S x - W z.$$

On the left-hand side of the arch the bending moment at H′ J′ is similarly given by :—

$$M' = N + P y - S x.$$

For simplicity let the half-span be unity, and let k be the distance of W from the centre line of the arch. Then the work done in bending the arch is :

$$U = \int_0^{s_k} (N + P y + S x)^2 \frac{ds}{2EI} + \int_{s_k}^{s_1} [N + P y + S x - W(x - k)]^2 \frac{ds}{2EI} + \int_0^{s_1} (N + P y - S x)^2 \frac{ds}{2EI}.$$

By Castigliano's principle this must be a minimum with respect to N, P, and S. That is :—

$$\frac{dU}{dN} = \frac{dU}{dP} = \frac{dU}{dS} = 0.$$

But

$$\frac{dU}{dN} = \int_0^{s_k} (N + P y + S x) \frac{ds}{EI} + \int_{s_k}^{s_1} [N + P y + S x - W(1 - k)] \frac{ds}{EI} + \int_0^{s_1} (N + P y - S x) \frac{ds}{EI}.$$

Fig. 3.

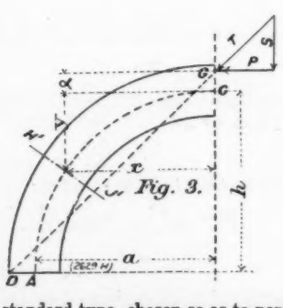
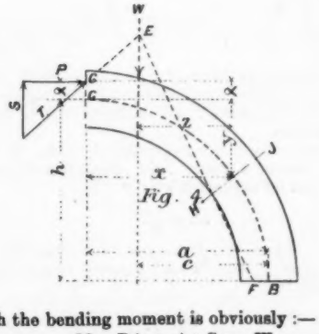


Fig. 4.



This reduces to :—

$$\frac{dU}{dN} = 0 = 2\int_0^{s_1} (N + P y) \frac{ds}{EI} - W \int_k^{s_k} (x - k) \frac{ds}{EI}.$$

But, in M. Mesnager's standard arch,

$$\frac{ds}{I} = \frac{dx}{I_0}.$$

$$\therefore 2\int_0^1 (N + P y)\, dx - W \int_k^1 (x - k)\, dx = 0 \quad . \quad (1)$$

Similarly, from $\frac{dU}{dP} = 0$, we get :—

$$2\int_0^1 (N + P y)\, y\, dx - W \int_k^1 (x - k)\, y\, dx = 0 \quad . \quad (2)$$

whilst $\frac{dU}{dS} = 0$ gives :—

$$2\int_0^1 S x^2\, dx - W \int_k^1 (x - k)\, x\, dx = 0 \quad . \quad . \quad (3)$$

The arch being parabolic, $y = f x^2$. On making this substitution, and effecting the integrations, we get :—

$$2N + \frac{2}{3} P f = \frac{W}{2}(1 - k)^2$$

$$\frac{2}{3} N + \frac{2}{5} P f = \frac{W}{12}(3 - 4k + k^4)$$

and

$$S = \frac{2 - 3k + k^3}{4}.$$

Solving for N and P we get :—

$$N = \frac{1}{32}(3 - 16k + 18k^2 - 5k^4).$$

$$P f = \frac{15}{32}(1 - 2k^2 + k^4).$$

The bending moment at T (Fig. 1) is therefore :—

$$N + P y + S k = P(y + E C).$$

$\therefore$ E C, the height of the point R above the level of the crown of the arch, is given by :—

$$E C = \frac{N + S k}{P} = \frac{3 - 6k^2 + 3k^4}{32} \cdot \frac{32 f}{15(1 - 2k^2 + k^4)} = \frac{f}{5}.$$

The moment at the left-hand abutment is (Fig. 1) :—

$$P \times L A = N + P f - S.$$

$$\therefore L A = \frac{N + P f - S}{P} = \frac{2f}{15} \cdot \frac{1 + 4k - 6k^2 - 4k^3 + 5k^4}{1 - 2k^2 + k^4} = \frac{2f}{15} \frac{1 + 5k}{1 + k}.$$

$$\therefore F L = \frac{6}{5} f - \frac{2}{15} f \frac{1 + 5k}{1 + k} = \frac{8}{15}\left(\frac{2 + k}{1 + k}\right) f.$$

But if H R cuts O E at c

$$F L = 2 F H - E c,$$

and

$$E c = F H \cdot \frac{k}{1 + k}.$$

$$\therefore F L = F H\left(2 - \frac{k}{1 + k}\right) = F H \cdot \frac{2 + k}{1 + k},$$

and

$$F H = \left(\frac{1}{5} + \frac{1}{3}\right) f = \frac{8}{15} f,$$

$$\therefore F L = \frac{8}{15} \cdot \frac{2 + k}{1 + k} f,$$

which is the value found by calculation.

Similarly :—

$$G M = \frac{8}{15} \cdot \frac{2 - k}{1 - k} f,$$

both by construction and by calculation.

ON THE WHIRLING SPEEDS OF LOADED SHAFTS.

By WILLIAM KERR, A.R.T.C.

(*Concluded from page 226.*)

APPENDIX A.

ALTERNATE DISCUSSION.

THE essential points of the result already given may be arrived at in a somewhat simpler and briefer fashion, if we neglect I^2, and deal directly with the forces. It was, in fact, by this method that the result was first obtained, but it was rejected in favour of the more complete investigation rendered possible by the employment of Lagrange's equation.

In the following equations let :—

m = deflection of shaft,
ϵ = elastic force of shaft per unit deflection,
e = eccentricity of load,
and all other symbols as before.

If angular velocity is ω, then, when angle ωt has been turned through (Fig. 12), we have, considering the forces on the wheel :—

External Forces :—

$+ \epsilon m$ the elastic force of the shaft.
$+ W . \sin \omega t$ the component of gravity in the direction of the deflection.

Effective Forces :—

$+ \frac{W}{g} \omega^2 (m + e) - \frac{W}{g} . \ddot{m}$ the total radial accelerating forces.

Hence, by reversing the effective forces, and adding and equating to zero (after the well-known principle of dynamics), we get :—

$$\epsilon . m + W . \sin \omega t - \frac{W}{g} . \omega^2 (m + e) + \frac{W}{g} \ddot{m} = 0,$$

i.e. :—

$$\frac{W}{g} . \ddot{m} + m \left(\epsilon - \frac{W}{g} \omega^2 \right) = \frac{W}{g} . \omega^2 . e - W . \sin . \omega t,$$

or

$$\ddot{m} + m \left(\frac{\epsilon g}{W} - \omega^2 \right) = \omega^2 . e - g . \sin \omega t \quad . \quad . \quad (a')$$

and this equation corresponds to (q). Considering the particular integral, we have :—

$$m = \frac{1}{D^2 + \left(\frac{\epsilon g}{W} - \omega^2 \right)} \left\{ \omega^2 . e - g . \sin \omega t \right\}$$

$$\left(D \text{ denotes } \frac{d}{dt} \right)$$

$$= \frac{\omega^2}{\frac{\epsilon g}{W} - \omega^2} . e - \frac{g}{\frac{\epsilon g}{W} - 2 \omega^2} \sin \omega t \quad . \quad (b^1)$$

From this equation we get m infinite for either of the two conditions :—

$$\omega^2_c = \frac{\epsilon g}{W}, \text{ or } 2 \omega^2_c = \frac{\epsilon g}{W}.$$

These conditions correspond exactly with those obtained by the complete investigation. The actual values require, of course, a separate determination of ϵ. The final result by this method would not, however, be in complete agreement with that already given, as I′ has been neglected here, and not in the other.

Running Above the Critical Speed.—It may be of interest to investigate the effect of applying our equation to the running of the shaft above the critical speed—*i.e.*, when $\omega^2 > \frac{\epsilon g}{W}$.

Equation (a^1) then becomes :—

$$\ddot{m} - m \left(\omega^2 - \frac{\epsilon g}{W} \right) = \omega^2 . e - g . \sin \omega t \quad (a^{11})$$

and for the particular integral we have :—

$$m = \frac{\omega^2}{D^2 - \left(\omega^2 - \frac{\epsilon g}{W} \right)} . e - \frac{g}{D^2 - \left(\omega^2 - \frac{\epsilon g}{W} \right)} . \sin \omega t.$$

$$= \frac{\omega^2}{\omega^2 - \frac{\epsilon g}{W}} (- e) - \frac{g}{2 \omega^2 - \frac{\epsilon g}{W}} . \sin \omega t. \quad . \quad (b^{11})$$

From this equation it will be seen that, as ω becomes very great, m tends towards the value $(- e)$. The physical interpretation of this is that, at high speeds, the shaft deflects to such an extent as would bring the centre of gravity of the load coincident with the axis of rotation.

This result would also seem to be in agreement with that of Foppl. It has been impossible to obtain the method of analysis employed by Foppl, but Stodola states* that "Foppl in his theoretical investigations, under simplified assumptions, proved that conditions represented in Fig. 13 give not only a probable, but a stable, equilibrium." On the strength of this it can be easily shown that, with ω infinite, the deflection of the shaft $= e$.

It is, however, to be noted that there is a weakness in the application of our equation to running above the critical speed. This weakness lies in the fact that the complementary function of (a^{11}) involves exponential terms. The complementary function is :

$$m = A \, \epsilon^{\sqrt{\omega^2 - \frac{\epsilon g}{W}} . t} + B \, \epsilon^{- \sqrt{\omega^2 - \frac{\epsilon g}{W}} . t}$$

(where ϵ in this case is the base of the natural logarithms).

* Stodola, "Steam Turbines," 2nd (English) Edition, page 180.

Consequently, unless it could be shown that these terms vanish (in the general problem), we would apparently have a steady growth of the deflection, even at constant speed, if that speed were above the higher critical value. From experience we know, of course, that such a condition is impossible.

APPENDIX B.

BAUMANN'S RULE.

In a paper* published in 1912, Mr. K. Baumann gives a simple rule for the calculation of the ordinary critical speed value, which should be more widely known than it would seem to be. Mr. Baumann says : "By well-known methods the critical speed and deflection due to gravity were calculated as accurately as possible by different engineers . . . with the invariable result that :—

$$\omega^2_c = (1.07 \text{ to } 1.08) \frac{g}{f} \quad . \quad . \quad (c^1)$$

where f is the deflection due to gravity."

By Method I. we have in the process of obtaining the critical speed measured the maximum deflection due to gravity. This deflection is 0.003357 in. Using the above equation :—

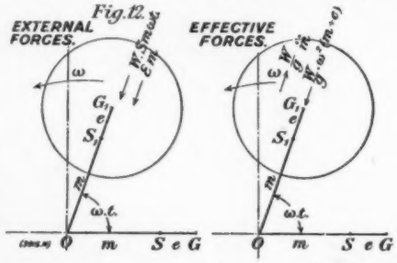
$$\omega^2_c = 1.07 \frac{g}{f}$$

we find the critical speed to be :—

$$N_c = \frac{30}{\pi} \omega_c = \frac{30}{\pi} \sqrt{\frac{1.07 \times 32.2 \times 12}{0.003357}} =$$

3352 revolutions per minute,

and this result is in close agreement with the



result obtained by Method I., which is 3338 revolutions per minute. Evidence of this nature is, however, unnecessary, as equation (c^1) is quite sound in form.

We have shown in Appendix A how, in the general case of a single load, the critical speed (higher) can be expressed by :—

$$\omega^2_c = \frac{\epsilon g}{W},$$

where ϵ is the elastic force per unit deflection at the load point. Now in such a case it can be easily shown that :—

$$\frac{\epsilon}{W} = \frac{1}{f_1},$$

where f_1 is the static deflection under the load. Hence we have that :—

$$\omega^2_c = \frac{g}{f_1};$$

but since the maximum deflection f will be somewhat greater than f_1, we have :—

$$\omega^2 = c \frac{g}{f},$$

where c is some constant greater than unity. In the case of single loads, the value of f is never very much greater than f_1, so that c will, in most practical cases, be not much greater than unity.

On the whole, this rule would seem to be of great value in practical design, where, in general, graphical methods of computation must be resorted to. It is much easier to determine the static deflection, and apply (c^1), than to carry out either of the methods I. and II. It is to be realised, of course, that, with extreme systems of loading, some slight modification of the constant may be necessary.

It would seem desirable to express the "new" critical speed value by an equation similar to (c^1). This is readily done from the apparently general relation which we have obtained—*i.e.* :—

$$\omega^2_c = 2 \omega^2_k$$

Hence we have :—

$$\omega^2_k = (0.53 \text{ to } 0.54) \frac{g}{f} \quad . \quad . \quad (d^1)$$

These two equations, (c^1) and (d^1), will permit of both critical speeds being obtained from a single graphical computation of the static deflection. The use of this method is to be recommended, as it is fairly simple and is as accurate as the knowledge of the conditions of the problem usually warrants.

* "Recent Developments in Steam-Turbine Practice," K. Baumann, Proceedings of the Institution of Electrical Engineers, January 16, 1912.

APPENDIX C.

ON DUNKERLEY'S FORMULA.

In dealing with multiple loads on a shaft, direct calculation (without graphical methods), embracing at once all the loads on the shaft, is practically impossible. For this purpose Dunkerley proposes, and also extensively uses, a type of equation the approximate truth of which has been fairly well established by his experiments. If a shaft carries several loads, the critical speeds due to each considered separately as a single load on a massless shaft being N_1, N_2, N_3 . . ., while the critical speed of the unloaded shaft is N^1; then the Dunkerley formula states that the critical speed of the combination (N) is given by :—

$$\frac{1}{N^2} = \frac{1}{N_1^2} + \frac{1}{N_2^2} + \frac{1}{N_3^2} + \ldots + \frac{1}{N'^2}.$$

This equation has been arrived at by the following process :—*

If a spring supports a weight W_1, and the elastic force of the spring is ϵ lb. per foot deflection, then

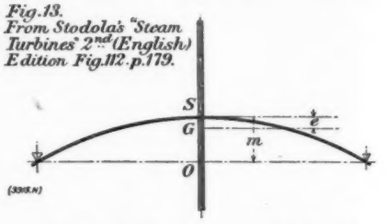


Fig. 13. From Stodola's "Steam Turbines" 2nd (English) Edition Fig. 112. p. 179.

the number of vibrations per second is given by :—

$$N_1^2 = \frac{g \epsilon}{W_1}.$$

If a second weight W_2 be now attached at the same point, we get (if W_1 be absent) :—

$$N_2^2 = \frac{g \epsilon}{W_2}.$$

Hence we have for both together :—

$$N^2 = \frac{g \epsilon}{W_1 + W_2} = \frac{N_1^2 . N_2^2}{N_1^2 + N_2^2};$$

$$\therefore \frac{1}{N^2} = \frac{1}{N_1^2} + \frac{1}{N_2^2}.$$

This type of equation is used by Dunkerley for even fairly elaborate systems of loading, although he states that modification by a constant is probably desirable in many cases.

Dr. Chree, in referring to this formula, says that, under certain circumstances, an equation of this type—*i.e.*, Dunkerley's equation—may be shown to be true for vibration frequencies. But these circumstances seem to include the assumption that the force of restitution will remain the same whether we apply one or a series of loads; and he gives a demonstration of the truth of the equation on this assumption. But this takes us no further than Dunkerley has already done. That the force of restitution should remain the same for any arrangement of loads is too improbable to justify the assumption. Dr. Chree realises this when he states later,† "even if we assume that what is true of transverse vibrations is true of whirling, we would have to prove that the addition of pulleys at different parts of a shaft is equivalent to varying the load without affecting the force of restitution."

At one point in this work the present writer was desirous of obtaining some idea of the nature and probable magnitude of the differences between the results obtained by the Dunkerley formula and those deduced by more correct methods. The general problem of the vibration frequency of a massless shaft carrying a number of loads would

* Dunkerley's paper.
† Dr. Chree's paper.

seem to be practically impossible, on account of the unwieldy and unsymmetrical nature of the mathematical expressions. This is so even if there are only two loads—that is, of course, when treated generally.

It therefore seemed that the only way to obtain the required information would be to simplify the problem, by dealing only with symmetrical systems of loading. The determination of the natural frequency of a massless shaft with two loads is with such a simplification quite easy, and it is given below. In the case of a greater number of loads, difficulty is encountered if the shaft deflection is dealt with in the usual way. A special method is therefore used, and the case of three loads is given as an illustration. An investigation of the case of a uniformly-distributed load is also given.

The results obtained provide fairly clear evidence that the Dunkerley formula gives results that are usually on the low, and, therefore, on the safe, side. We only deal with vibration frequencies, since that is the basis of the Dunkerley formula, and since we have in any case to neglect I′ for the sake of simplicity. But as it is merely differences we want to get at, the results must be closely applicable to whirling speeds.

Fig. 14. APPENDIX C. CASE I—MASSLESS SHAFT WITH TWO EQUAL LOADS.

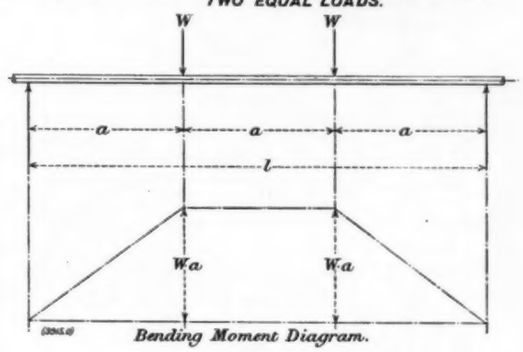


Fig. 15. APPENDIX C. CASE II—MASSLESS SHAFT WITH THREE EQUAL LOADS.

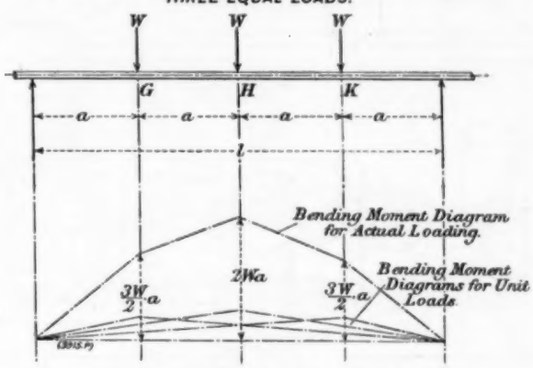
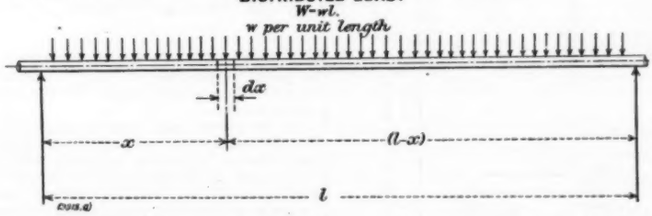


Fig. 16. APPENDIX C. CASE III—MASSLESS SHAFT WITH UNIFORMLY DISTRIBUTED LOAD.



Case I. Massless Shaft Carrying Two Equal Loads Symmetrically Placed. (See Fig. 14.)

From symmetry the deflections under the loads will be the same, say $= z$.

Hence the strain energy of the bent shaft is :—

$$S = 2\left(\tfrac{1}{2} W . z\right).$$

But the strain energy is also given by :—

$$\frac{1}{2 E I}\int_0^l M^2 . dx = \frac{1}{E . I} A \bar{y},$$

where A is the area of the bending-moment diagram, and $\bar{y}$ is the ordinate of its centre of gravity.

Hence :—

$$S = \frac{1}{E . I}\left\{2\left(\frac{W a^2}{2} \times \frac{W a}{3}\right) + \left(W a^2 \times \frac{W a}{2}\right)\right\}$$

$$= \frac{5 W^2 a^3}{6 E I};$$

$$\therefore\ 2\left(\tfrac{1}{2} . W . z\right) = \frac{5 W^2 a^3}{6 E I};$$

$$\therefore\ z = \frac{5 W a^3}{6 E I}.$$

When the shaft vibrates, the strain energy in the bent position will be equal to the kinetic energy when passing through its undeflected position; hence :—

$$\frac{5 W^2 a^3}{6 E I} = \tfrac{1}{2} . \frac{2 W}{g} . \rho_A^2 . \left(\frac{5 W a^2}{6 E I}\right)^2.$$

$$\therefore\ \rho_A^2 = \frac{6 . g . E . I}{5 W a^3} = 32.4 \frac{g . E . I}{W . l^3} \quad . \quad (c^1)$$

ρ_A = the angular velocity of a point, moving in a circle of radius z, and defining the simple harmonic vibration.

The frequency of transverse vibrations $= \rho_A / 2\pi$.

From the Dunkerley formula we have :—

$$\frac{1}{\rho_b^2} = \frac{1}{\rho_1^2} + \frac{1}{\rho_2^2}.$$

It can be easily shown that ρ^2 for either of the two loads is :—

$$\frac{3 . g . E . I . l}{W . a^3 . (2a)^2}.$$

Hence :—

$$\frac{1}{\rho_b^2} = \frac{2 \times W . a^2 . 4 a^2}{3 . g . E . I . 3a} = \frac{8 . W . a^4}{9 . g . E . I . a}$$

$$\therefore\ \rho_b^2 = \frac{9 . g . E . I}{8 . W . a^3} = 30.37 \frac{g . E . I}{W . l^3} \quad . \quad (f^1)$$

Hence the error in ρ (which may be taken as the error in critical speed) due to calculation by Dunkerley's formula is: —

$$100\left(\frac{\sqrt{32.4} - \sqrt{30.37}}{\sqrt{32.4}}\right) = 3.2 \text{ per cent.}$$

Case II. Massless Shaft Carrying Three Equal Loads Equally Pitched. (See Fig. 15.)

From consideration of the bending-moment diagram as before, for the strain energy of the bent shaft, we have :—

$$S = \frac{1}{E I}\left\{2\left(\frac{3 W a}{2} . \tfrac{1}{2} a . \tfrac{1}{3} . \frac{3 W a}{2}\right) + \left(\frac{3 W a}{2} . 2a . \tfrac{1}{3} . \frac{3 W a}{2}\right) + \frac{W a^2}{2}\left(\frac{3 W a}{2} + \tfrac{1}{3} . \frac{W a}{2}\right)\right\}$$

$$= \frac{46 W^2 a^3}{12 E I}.$$

We now require to determine the deflections at the load points. Obviously the deflections will be the same at G and K. To determine these deflections in the usual way means that we have first to find the equations to the deflected shaft. This is a very involved process, and, instead, we here make use of a special theorem known as "Frænkel's theorem." This theorem states that the deflection at any point of a shaft is given by :—

$$\delta = \int_0^l \frac{M . m . ds}{E I},$$

where M is the bending moment due to the actual loading; m is the bending moment due to a unit load, placed at point where deflection is required.

We will replace ds by dx, which is justifiable in view of the small deflections.

(*a*) *Deflection at G and K. Outer Loads :—*

$$\int_0^l \frac{M . m . dx}{E I} = \frac{1}{E I}\left\{\int_0^a \left(\frac{3 W}{2} x . \frac{3}{4} x\right) dx + \int_0^a \left\{\frac{3 W}{2}(a + x) - W x\right\}\left\{\frac{1}{4}(3a - x)\right\} dx + \int_0^a \left\{\frac{3 W}{2}(a + x)\right\}\left\{\frac{1}{4}(a + x)\right\} dx + \int_0^a \left(\frac{3 W}{2} x . \frac{1}{4} x\right) dx\right\},$$

from which we get the deflection $= \frac{9 W a^3}{4 E I}$.

(*b*) *Deflection at H. Central Load.*

$$\int_0^l \frac{M . m . dx}{E I} = \frac{2}{E I}\left\{\int_0^a \left(\frac{3 W}{2} x . \tfrac{1}{4} x\right) dx + \int_0^a \left\{\frac{3 W}{2}(a + x) - W x\right\}\left\{\tfrac{1}{4}(a + x)\right\} dx\right\},$$

from which we get the deflection $= \frac{19 W a^3}{6 E I}$.

The kinetic energy is therefore :—

$$\tfrac{1}{2} . \frac{2 W}{g} . \rho_A^2 . \frac{81 . W^2 . a^6}{16 E^2 I^2} + \tfrac{1}{2} . \frac{W}{g} . \rho_A^2 \frac{361 W^2 a^6}{36 E^2 I^2}.$$

Hence equating strain energy to kinetic energy :—

$$\frac{46 W^2 a^3}{12 E I} = \frac{W^2 . a^6}{g E^2 I^2} . \rho_A^2 \left\{\frac{81}{16} + \frac{361}{72}\right\}.$$

$$\therefore\ \rho_A^2 = \frac{552 g E I}{1451 W a^3} = 24.34 \frac{g . E . I}{W l^3}.$$

From the Dunkerley formula we have :—

$$\frac{1}{\rho_b^2} = \frac{1}{\rho_1^2} + \frac{1}{\rho_2^2} + \frac{1}{\rho_3^2}.$$

Hence :—

$$\frac{1}{\rho_b^2} = \frac{2 . W . a^2 . (3a)^2}{3 . g . E I . 4a} + \frac{W . (2a)^2 . (2a)^2}{3 . g . E . I . 4a}$$

$$\therefore\ \rho_b^2 = \frac{6 . g . E . I}{17 W a^3} = 22.59 \frac{g . E . I}{W l^3}.$$

Hence the error in ρ due to calculation by Dunkerley's formula is :—

$$100\left(\frac{\sqrt{24.34} - \sqrt{22.59}}{\sqrt{24.34}}\right) = 3.7 \text{ per cent.}$$

Case III. Massless Shaft Carrying Uniformly-Distributed Load. (See Fig. 16.)

The natural frequency in this case is a standard text-book example, and we may write at once :—

$$\rho_A^2 = 97.55 \frac{g . E . I .}{W . l^3}$$

where W = total load $= w l$.

In applying Dunkerley's formula in this case we suppose the shaft divided up into infinitesimal portions, and deal with a massless shaft carrying a load equal in weight to that on the infinitesimal portion.

Let dx be portion at distance x from origin at left-hand end, then :—

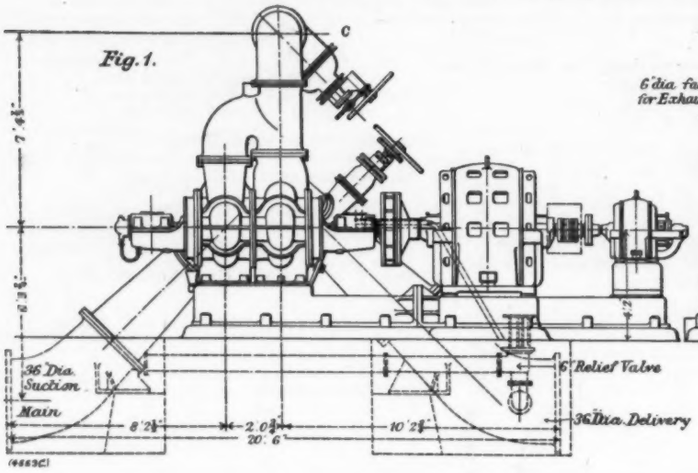
$$\rho_x^2 = \frac{3 . g . E . I . l}{w\, dx\, x^2 (l - x)^2}$$

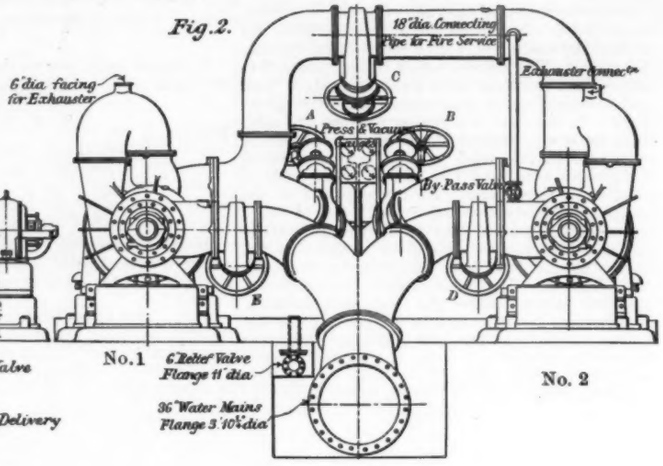
w = load per unit length.

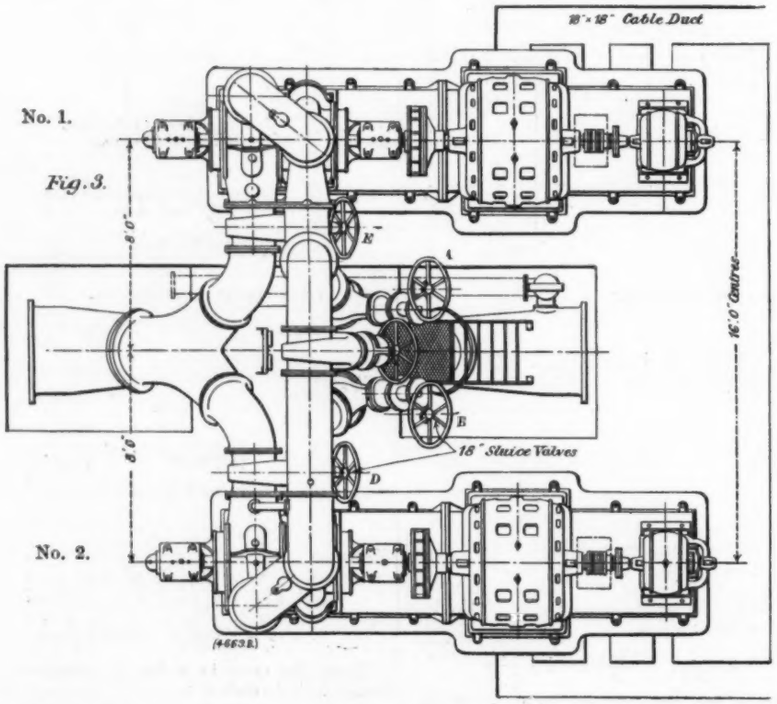
$$\therefore\ \frac{1}{\rho_x^2} = \frac{w}{3 . E . I . g . l} x^2 (l - x)^2\, dx.$$

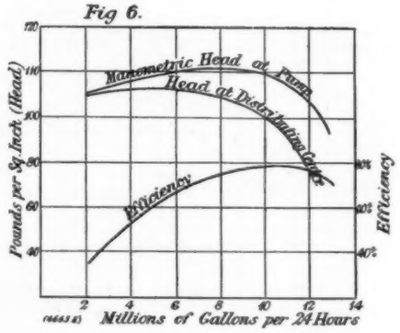
HIGH-PRESSURE CENTRIFUGAL PUMPING PLANT AT EDMONTON, CANADA.

CONSTRUCTED BY MESSRS. DRYSDALE AND CO., LIMITED, ENGINEERS, GLASGOW.









Now, by Dunkerley's formula :—

$$\frac{1}{\rho_0^2} = \frac{1}{\rho_{s_1}^2} + \frac{1}{\rho_{s_2}^2} + \ldots = \Sigma \frac{1}{\rho_s^2}.$$

$$\therefore \frac{1}{\rho_0^2} = \frac{w}{3.E.I.g.l}\int_0^l (x^3 l^3 - 2lx^3 + x^4)\,dx$$

$$= \frac{w\,l^4}{90.E.I.g}$$

$$\therefore \rho_0^2 = 90\,\frac{g.E.I}{W\,l^3}.$$

Hence the error in this case, due to calculation by Dunkerley's formula, is :—

$$100\left(\frac{\sqrt{97.55} - \sqrt{90.0}}{\sqrt{97.55}}\right) = 3.95 \text{ per cent.}$$

From these three investigations we see how the Dunkerley formula seems, in general, to give a low result. It is also to be noted that the error is very much the same for all three cases, being—

3.2 per cent. low for two loads.
3.7 ,, ,, three loads.
3.95 ,, ,, uniform loading.

The nature of these results shows that the force of restitution does not remain the same whether we apply one or a series of loads. Nevertheless, it would seem as if the force of restitution tended to a constant value as the number of individual loads increases.

The designer should therefore realise that by the use of the Dunkerley formula (in practical cases of simply supported shafts at least) he obtains a margin of safety of approximately 4 per cent.

HIGH-PRESSURE CENTRIFUGAL PUMPING PLANT AT EDMONTON, CANADA.

GRAVITATION systems of water supply to the growing cities in the plains of Canada cannot well be adopted under present conditions, and recourse must be had to pumping. In many instances of late years it has been found advantageous, all things considered, to employ for this purpose centrifugal rather than reciprocating pumps, in spite of the very high thermodynamic and mechanical efficiency of the latter when operating at high lifts. These advantages are, however, in many cases outweighed by the lower first cost, both direct and indirect, of centrifugal plant, and its easy maintenance. There is, moreover, the added convenience that when electrically driven, centrifugal pumps may be placed where most convenient from the standpoint of hydraulics, without regard to the situation of the power-house.

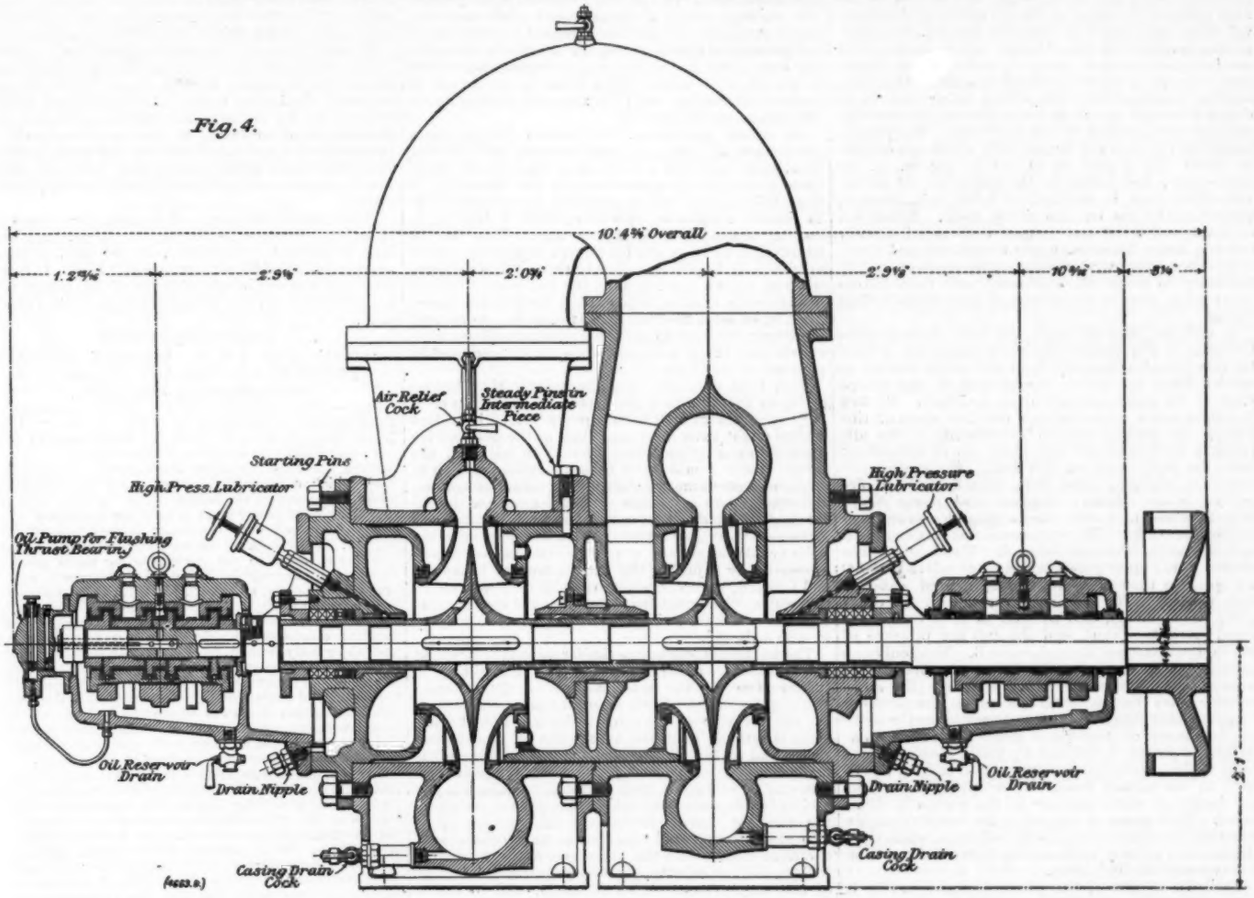
On the present and opposite pages we illustrate a high-lift centrifugal pumping plant erected at Edmonton, Alberta, by Messrs. Drysdale and Co., Limited, Ferry-road, Yoker, Glasgow, to the order of Mr. R. H. Parsons, Assoc. M. Inst. C.E., at that time in charge of the water and electricity supplies of the city. There are two sets of pumps, each of which is capable of delivering 10 million gallons per 24 hours at a pressure of 110 lb. per sq. in. Each unit is direct coupled to an auto-synchronous motor of 850 brake horse-power, operating with 2200-volt three-phase sixty-cycle alternating current, supplied by the City Power Plant. The selection of auto-synchronous motors for driving these pumps was decided on because of the great ease of starting as compared with motors of the ordinary synchronous type, and because of the possibility of correcting lagging currents, by means of leading current in the motors by suitable adjustment of the exciter current, thus materially benefiting the power factor of the generating station.

The general arrangement of the pumping plant is shown in Figs. 1, 2, and 3, on the present page. The pumps are connected to suction and discharge-pipes, each of 36-in. bore, the water dealt with being taken from a sump situated inside the pump-room. This water is first of all lifted from the Saskatchewan River by low-pressure pumps and delivered into a settling-pond, thence gravitating through a series of mechanical filters to the sump above mentioned. The discharge main is directly connected to the pipe-network of the city of Edmonton, which extends on both banks of the Saskatchewan River. Non-return multiple flap-valves are placed in the rising mains, so that, in the event of a shut-down of the pumps from any cause, the contents of the city pipe-lines cannot run back. In order to meet the contingency of a stoppage in the electricity supply, a steam-driven pump is also provided, which can maintain during repairs an emergency supply to the city. Venturi meters are also placed in the rising main, so that a record of water used may be obtained, and the economy of the plant checked or corrected. The maximum estimated capacity for a considerable time to come

HIGH-PRESSURE CENTRIFUGAL PUMPING PLANT AT EDMONTON, CANADA.

CONSTRUCTED BY MESSRS. DRYSDALE AND CO., LIMITED, ENGINEERS, GLASGOW.

Fig. 4.



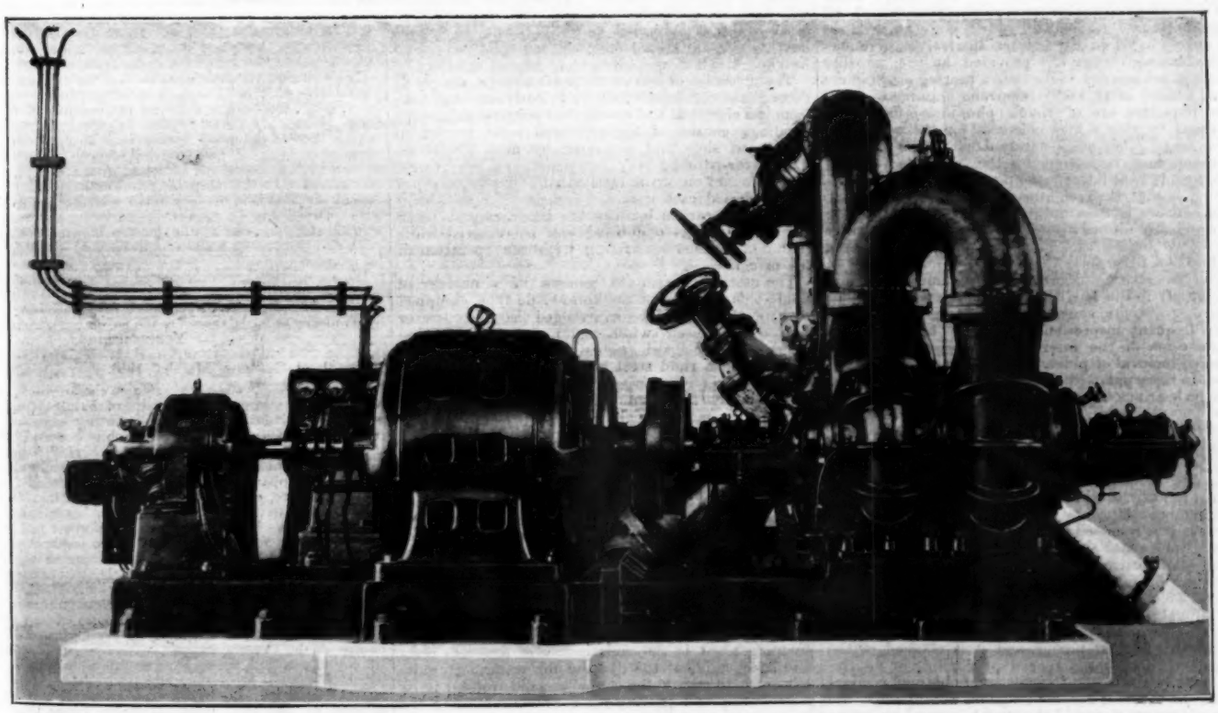


FIG. 5.

will be under 10 million gallons per day, and thus one unit is sufficient to provide for all requirements.

The grouping of the control-valves is so arranged that there is no cessation in supply when changing over from one pump to the other, and in view of the high pressure prevailing on the delivery side, the sluice-valves are provided with reduction gearing, thus minimising the labour of the attendant and making quicker manipulation possible when it is desired to change over. Isolating valves are fitted on each of the pump suction branches, thus permitting either unit to be drained out and opened up for inspection, without disturbing the operation of the other set. The pumps, when run together and connected in series, are capable of developing a pressure of 160 lb. per sq. in. for fire service, and owing to the disposition of valves, very little time is required to bring this increased pressure into use on the rising main. When fire service is called for, one or other of the sets is already running under domestic supply conditions, and therefore to bring the extra pressure on the mains, it is only necessary to prime the stationary unit from the delivery main, start up the motor and open up the various valves.

It will be observed from the valve arrangements indicated in Fig. 2 that only three stages are utilised for this duty, the delivery from the pump already in service being coupled to the suction of the second stage of the pump, brought in as auxiliary. No flow therefore takes place through the first stage of this pump. To protect against overheating of the idle stage, a by-pass is provided which can be opened out after the pumps are on full load. The routine followed in changing over from normal duty to fire service is as follows:—Suppose that pump No. 1 (Fig. 2) is that in service, discharging at a pressure of 110 lb. per sq. in. The water enters through valve E and discharges through valve A. Valve D, on the suction of the other pump, is shut, but valves B and C are open, so that pump No. 2 is filled with water at high pressure. To get it in series with the other pump, it is started, and as soon as it is running at speed valve A is shut, and the full fire pressure of 160 lb. is discharged through valve B. Thus only one valve has to be manipulated. When the fire service is no longer required, the pump giving the extra pressure may be cut out, whereupon the pressure drops to that required by the domestic supply without fluctuation or cessation of flow. The initial priming of the pumps is effected by steam-ejectors, there being no foot-valve or other obstruction causing loss of head on the suction main. By adopting this means the danger of water-hammer in the pumps is eliminated. Each pump is coupled to its motor through a shrouded flexible coupling of the belt type, while rigid alignment is secured by mounting pump and motor on a heavy cast-iron bed-plate.

A section of one of the pumps is shown in Fig. 4, page 249, a special feature of the design being the provision made for the ready renewal of all wearing parts. The shaft between the stuffing-boxes is entirely cased in hard-bronze sleeves, while renewable clearance-rings are provided at the impeller eyes and peripheries. The centre bearing is of lignum vitæ, housed in an easily-removable gun-metal shell. The impellers are of tough phosphor-bronze, and designed to give a high efficiency for the conditions prevailing. They are securely fixed to the shaft by feathers, and registered by the shaft-sleeves and lock-nuts; these latter being placed outside the pump-casing, so that their tightness may be verified at any time. There is thus nothing inside the pump-casing on which any fibrous matter entering with the water can be entangled, the rotor presenting everywhere a surface free from projections.

The importance of accessibility in pumps of this size lies largely in the fact that a machine which can be dismantled easily generally receives greater care and more frequent inspection than would be the case if examination of the interior or withdrawal of parts entailed removal of pipes, valves, or other heavy castings. In these pumps the removal of the outer end cover with its bearings exposes the first-stage impeller. When this is withdrawn, the intermediate piece can be removed, and it may be noted that a special non-rusting liner and the provision of bushed plugs for the insertion of drawing-bolts ensure that there will be no difficulty in doing so. All bearings for both motors and pumps are of the oil-ring lubricated type, thus giving a minimum outlay on oil; and the complete bushes can, moreover, be removed without disturbing the shafting. A multiple collar-thrust bearing is embodied in the outer pump-bearing, and shown to the left of Fig. 4. This bearing is lubricated by oil passing through a central hole in the shaft, whence it is distributed by centrifugal action.

It will be observed from Fig. 4 that there are no guide-vanes in these pumps, and it is claimed by the makers that with the special proportions of volutes and impellers adopted the efficiency obtained is equal to that of the best turbine (or guide-vane) pumps, the accessibility greater, and the initial cost and maintenance considerably less. Further, overloads can, it is stated, be taken much more readily than with a turbine-pump, and there is not the same danger of breakages due to the passage of solids in the form of loose timber, stray bolts, &c., which can sometimes gain access into even the best-protected pipe systems. The castings are of a special tough grade cast iron, amply strengthened, and are designed to withstand a test pressure of 350 lb. per sq. in. Particular attention has been given to the draining arrangements, so that in the event of severe frost, there is no danger of cavities containing water freezing, and putting excessive strains on the castings.

As stated previously, the motors driving these pumps are of the auto-synchronous, self-starting type, each rated for a continuous load of 850 brake horse-power, the temperature rise not exceeding 70 deg. Fahr. above the surrounding atmosphere after 24 hours' continuous operation, with a lagging or leading power-factor of 80 per cent. This can be adjusted to unity by exciter current regulation, whilst overloads of 50 per cent. can be carried for 5 minutes without undue heating, and 100 per cent. overload momentarily without injury from mechanical stress, heating, or other causes. The efficiencies guaranteed are 93 per cent. at 25 per cent. overload, 93 per cent. at full load, 92 per cent. at three-quarter load, and 89 per cent. at half load.

This type of motor was adopted by Mr. Parsons owing to the trouble experienced in starting up ordinary synchronous motors on a pump load. Induction motors might have been used, but as the pumps were normally running under much less than full load, the power factor would have been unsatisfactory. The autosynchronous motors start up like induction motors, and when up to speed the exciter-brushes are shifted forward by hand. This raises the exciter volts, and increases the exciter current in the windings until the poles are strong enough to pull themselves into phase. Moreover, by adjusting the exciter-brushes backward and forward, a considerable correction for power factor is possible. The machine will pull out of synchronism with an overload, and go back to synchronous speed as soon as it can.

The method of starting is similar to that of a wound rotor induction motor, the speed being brought up to synchronism by the manipulation of an external starting resistance placed alongside the switchboard. On the last step of the rotor resistance unit the machine is running as nearly as possible at synchronous speed, and at the proper moment the field-circuit is thrown on by means of a double-pole knife-switch. The exciter voltage is then adjusted by means of the exciter-brush gear, and when the proper value of the exciting current is obtained the machine drops into synchronism, and operates as an ordinary synchronous motor, with the difference, however, that it will not fall out of step and stop should the voltage of the supply circuit drop suddenly, due to short-circuit or excessive overload. In this case the motor will drop out of synchronism, but will continue to run as an ordinary induction motor. When the voltage has recovered, the machine will automatically drop into synchronism, and continue to operate as before.

The motor is of the revolving field type, and built throughout for continuous full-load running, both from the electrical and mechanical point of view. All windings consist of former-wound coils, carried in half-closed slots and protected by mica insulation. The stator-winding is Y connected, and the neutral point brought out to a terminal. The collector-rings are of chilled cast iron, and are provided with multiple copper-carbon brushes, the brush rigging being arranged so that one brush can be removed while running, without interfering with the operation of the machine.

The starting resistance consists of a number of single-pole switches of the knife-blade type, equipped with interlocking devices so arranged that the operator must cut out each switch in its turn, thus bringing the motor up to speed gradually. These switches are mounted on a rigid steel framework, containing the necessary grid resistances. The whole equipment is of absolutely fire-proof construction. The exciter regulator is mounted alongside the starter, so that adjustment of power-factor and synchronising can be carried out with a minimum of effort. The main oil-switch and instrument panels are of the Ferranti fire-proof mining type, each motor being supplied by a separate feeder from the generating station, so that the risk of breakdown is reduced to a minimum. All mountings necessary for the control and recording of electrical input are supplied, including ammeters, overload relays, no-voltage trips, voltmeters, and watt-hour meters. The general arrangement of the plant as installed is shown in Fig. 5, page 249, which we reproduce from a photograph.

A point of considerable importance in water-works pumping plant is the maintenance of constant pressure irrespective of the demand for water. By suitably proportioning the impeller and volute it is possible to give a delivery pressure which rises as the discharge increases, thus compensating for the frictional losses in the rising main and maintaining practically a constant pressure of water at the distributing centre up to and considerably over the normal capacity. These characteristics are embodied in the pumps described above, the general performance at synchronous speed being shown in the diagram, Fig. 6, page 248, together with frictional resistances in the pipes and pressure values at distributing centre.

In order to provide against overloads due to a break in the rising main, the design is arranged to give self-regulation in regard to the power absorbed with abnormal discharge, while, in addition, the circuit-breakers on the motor-panels are set to cut out at a predetermined overload, so that a "wash-out" is prevented in the event of the delivery main bursting, such an accident being accompanied by a large reduction in pressure and abnormal delivery at the pumping station.

With regard to pump efficiencies, the values obtained on test were 76 per cent. on 25 per cent. overload, 78 per cent. on full duty, 73 per cent. on three-quarter load, and 60 per cent. on half load. It is thus seen that the combined efficiency of the plant, from a power point of view, is high throughout the range of duty.

"THE 4600-I.H.P. MARINE DIESEL ENGINES OF THE M.V. 'CEARA.'"

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the article appearing in ENGINEERING of February 25, 1916, on the "Marine Diesel Engines of m.v. Ceara," I would like to point out some misleading statements made therein.

First, the total indicated horse-power is claimed at 4600, which apparently is correct; but later on in the table, and through the whole of the article, this 4600 indicated horse-power is set in as brake horse-power, and this is compared with the brake horse-power of other engines, thereby making the comparison altogether wrong. The same refers to the corresponding mean pressure, which is apparently for indicated horse-power, not for brake horse-power, as stated. Taking these statements into consideration, it therefore seems to me that the whole article is decreased in value, as it is quite possible that the oil consumption also is taken on the wrong basis, and apparently should be 0.44 lb. per indicated horse-power. The statement that the scavenge pump ratio is very ample is not correct. It is just what it should be for this size of engine for a good scavenge, and the average good combustion is no art where the engine only has a small maximum mean pressure, such as 68.5 lb. per sq. in. This apparently has nothing to do with the special form of the combustion space, as claimed in the article.

Further, the article talks a great deal about excellent cooling. The writer is apparently not aware that excellent cooling is a thing that is not wanted for a Diesel engine, as the more effective the cooling the higher are the stresses on the material and the lower the efficiency of the cycle. With reference to the weight comparison between the two-stroke and the four-stroke-cycle engines, I can say that up till now the weight of the four-stroke engines has been much less than the two-stroke, taking the same diameter and stroke into consideration, and for the same brake horse-power the weights are nearly the same, and in some cases less. There are already in service submarine motors of four-stroke lighter than the same horse-power in the two-stroke type.

The writer of the article states that the engines of the Ceara have an over-all length, including the flywheel, of 30 ft. 6 in., but on the drawing it measures 35 ft. 3 in. How is this explained? The 1450-brake-horse-power engine that is taken for comparison is apparently the Mississippi engine, the over-all length of which is 36 ft. 8 in., and not 46 ft., as stated in the article. It is also stated that this ship is of unusual interest; but I cannot see that it is of very much interest as compared with a Diesel ship for mercantile marine, seeing that it is a dépôt ship, and can lie idle for ten months out of the year, and need never stand rough seas and non-stop runs for months.

We are all very much interested in the evolution of the large two-stroke engine, but the design of the engine shown I do not think is a solution of the question, and is by no means so far advanced as the Sulzer two-stroke type.

Yours faithfully,

V. MICKELSEN.

Hyndland, Glasgow, March 3, 1916.

[Mr. Mickelsen, when he wrote on the 3rd inst., could not have been aware that in the issue of that date (page 215 *ante*) we published an *erratum*, pointing out that the power of the main engines of this ship is 4600 B.H.P., the substitution of "I.H.P." for "B.H.P." being a regrettable printer's error. This, however, might have been quite apparent to those conversant with Diesel-engine practice, especially in view of the fact that in other references in the article the brake horse-power was stated as 4600. The fuel-oil consumption at full power is, as given in the description, 0.44 lb. per brake-horse-power hour, and the design and the cooling of the main parts must be "excellent" from the Diesel-engine point of view to achieve this low consumption.

The relative volume of the scavenging pumps of this engine is ample, since the figure of 1.65 to 1.7 is average practice for this power and type of engine, and the pumps of the Ceara's engines, with a relative volume of 1.8, are the largest which have so far been built, and of which particulars have been published.

The weight per brake horse-power of the two-cycle engines of the m.v. Ceara is much lower than any figures hitherto published for four-cycle engines of the slow-running type, as is apparent from an inspection of

the various designs. A consideration of the increased cylinder dimensions with four-cycle engines shows this clearly. When dealing with the weights of engines working on the two and four-cycle principles it is inadmissible to compare engines of equal cylinder dimensions.

The fly-wheel is not included in the drawings published of the Ceara's engines; the over-all length given of 30 ft. 6 in. is exclusive of the small pumps at the forward end, since these can, if necessary, be placed elsewhere.

We hope shortly to publish particulars and drawings of this ship, and from these it will further be seen that there are many unusual and most interesting features. With a motor-ship of this type acting as a moving base for submarine and following the fleet, much arduous work may fall to her lot, and the main engines which we have so fully described, being the highest powered installed to date, mark a certain progressive step in the evolution of the marine Diesel engine.—ED. E.]

"THE DEVELOPMENT OF THE MILITARY AEROPLANE: THE QUESTION OF SIZE."

TO THE EDITOR OF ENGINEERING.

SIR,—I would like to offer a criticism on what is, perhaps, the most vital point of Mr. Lanchester's contentions on the question of aeroplane size, as stated in his article published in your issue of the 3rd inst. He says that, "on the basis of constant velocity, the span must vary as the square root of the gross weight," in other words, that the gross weight is directly proportional to surface, presumably in accordance with the classical formula of air resistance $R = k S v^2$.

Now since the final performance of any aeroplane depends essentially on how much of that performance is supplied by the normal gliding of the machine, this direct proportionality presupposes that two aeroplanes of the same pattern, but of different sizes, give the same gliding speed and the same gliding angle if their gross weights are proportional to their surfaces. But, as a matter of fact, they do not.

For instance, in a non-technical article which he published in *Land and Water* on February 17 last, Mr. Lanchester gave as an example that if an aeroplane with a span of 40 ft. weighs gross 2000 lb. the double scale enlargement should weigh 2000×4, or 8000 lb. In that case a reduced model, say, of one-eighth of the scale, should weigh $\frac{2000}{64}$, or just over 31 lb., but anyone who has any experience of gliders knows that a 5-ft. model weighing 31 lb. glides very much like a brick. On the other hand, a 40-ft. biplane weighing 2000 lb. glides comfortably at 1 : 6 or even 1 : 7, and, in fact, with 2000 lb. it is rather on the light side and does not glide at more than 46/48 miles.

It would be interesting to hear from Mr. Lanchester for what reason the law of proportionality on which he bases his conclusions should work upwards, when it is quite clear that it does not work downwards.

By means of some unpublished formulæ based on my personal gliding experiments, and on observations of existing aeroplanes, it is quite simple to account for the above discrepancy; but these formulæ show that there is a great deal to gain by much larger machines than those at present in existence. For obvious reasons, however, such information had better be kept out of the public Press at the present moment.

Mr. Lanchester refers to the Russian attempt at large dimensions more or less as an example of failure. He can only mean the Sykorski biplane, which appears to have been based on the figures I gave in 1912 for a 4½-ton economical and slow passenger machine (see "Aerophile," June 1, 1912). Built on that base, the Sykorski would, of course, be more or less a white elephant from the military point of view. We could, however, do something very different to that.

I need not point out that the question involved in this criticism is one of essential importance, and one which has unfortunately received very little attention, mainly because laboratory experiments are quite unable to give any clue to its solution, whilst free-flight experiments are beset with endless difficulties and mishaps which few men have the patience to face.

I am, yours truly,

JOSH WEISS.

Houghton, near Arundel, March 15, 1916.

"ON THE WHIRLING SPEEDS OF LOADED SHAFTS."

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Kerr, in his article on the above subject in your issue of March 3, deals with the case of a small De Laval turbine, but seems to have entirely overlooked the simplest method of treatment—viz., a shaft with a concentrated load simply supported at the bearings Nos. I. and II.

When due regard is taken of the running clearance required, the yielding of the material of the bush to the applied load and the deflection of the housing due to the same cause, I see no reason to consider journal I. as other than simply supported. In addition, when considering the length of the shaft affected, I would use the inside edge of bearing I., because when vibrations are set up the shaft will be deflected beyond its normal position, and the journal will bear "cape and corner" in the bearing, and therefore the reaction will act through a small area at the inner end of the bearing.

The reaction at bearing II. will be in the middle of the bearing, since the bearing can swivel. Also the short shaft between II. and III. is capable of allowing the necessary deflection for simple support. Beyond this point the portion of the shaft with the pinion need not concern us.

Also I suggest that 0.25 in. is too low for the mean diameter of the shaft, since the portion inside the wheel must be equal to, or greater than, 0.3137 in. I propose 9 mm., or 0.3542 in., in default of more precise data, and therefore take 0.28 in. as the mean diameter.

Using the formula:—

$$\omega^2 = \frac{3 E I l}{M c_1^3 c_2^3}$$

for a simply supported loaded massless shaft, and inserting the values:—

$d = 0.28$ in.
$l = 6.06$,,
$c_1 = 2.06$,,
$c_2 = 4.0$,,

I obtain

$$\omega = 950 \text{ radians per sec.},$$

or

$$N = 9000 \text{ r.p.m. approx.}$$

Using Mr. Kerr's value of the diameter (0.25 in.), I obtain

$$N = 7200 \text{ r.p.m. approx.}$$

So that the correct value should lie between these values.

I think, if Mr. Kerr made a test to find the critical speed when the machine was slowing down, he would obtain a lower value than 8640 revolutions per minute.

As I have had the opportunity of studying the performance of many machines as similar as the highest class of workmanship can produce, I should like to offer my conclusions on these:—

1. The critical speed calculated as above agrees very closely with the speed at which maximum vibration occurs.

2. Vibration commences about 15 per cent. below the critical speed and persists for about 6 per cent. above that speed.

In some cases no critical speed could be detected even when the turbine was run steadily at the speed producing maximum vibration in others.

Trusting that my experience may be of some interest to Mr. Kerr and others,

I remain, Sir, yours faithfully,

Glasgow, March 11, 1916. G. H. HENDERSON.

[To save time, we forwarded a proof of Mr. Henderson's letter to Mr. Kerr, whose reply we subjoin.—ED. E.]

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Henderson, in his letter dealing with my calculation of the critical speed of the small De Laval turbine rotor, apparently considers that the correct method would be to take the shaft as simply supported at bearings I. and II. He also suggests that the correct equivalent uniform diameter is 0.28 in., instead of the 0.25 in. which I have assumed.

Taking this latter point first, I may say that Mr. Henderson's method of arriving at this figure of 0.28 in. is hardly justifiable, as the diameter of the equivalent shaft is not the mean of the various diameters of the actual. Besides the diameters, the lengths and the positions of the various parts must be taken into account. This makes the assumption of the uniform diameter a matter of some little difficulty. Mr. Henderson has assumed the portion inside the wheel as 0.3542 in. I know that it is a little less than $\frac{7}{16}$ in., and take it at 0.4 in., but, after the usual construction of these small rotors, this larger diameter, which carries the wheel, occurs only for a fraction of the hub length—say about one-half.

I have made a graphical computation of the critical speed for the conditions which Mr. Henderson has stated, using the correct shaft diameters throughout, and find the result to be:—

$$N_c = 7100 \text{ revolutions per minute approx.}$$

As is easily deduced from the results given by Mr. Henderson, this gives an equivalent uniform diameter of about 0.248 in., and therefore merely verifies the figure which I have assumed throughout these calculations. This result also shows very clearly that short lengths of relatively large diameter near the middle of the span have really no great stiffening effect, and should not be allowed to influence one unduly in the fixing of the equivalent uniform diameter.

But while I have made this complete calculation on Mr. Henderson's conditions, I am far from believing these conditions justified. It constitutes, as he says, the simplest method of loading; but simplicity in such a case as this is no criterion of accuracy. My whole intention in presenting the results of the calculation for this small rotor was to show how impossible it is to obtain a reliable estimate of the critical speed when the terminal conditions are indefinite.

Mr. Henderson assumes bearing II. as a simple support, and that the length of shaft between II. and III. is capable of allowing for this. This is probably true in this particular case, but I prefer to consider the problem from the point of view of that one condition which cannot be gainsaid—viz., that bearings III. and IV. combined serve to fix the direction of the shaft at that end, and consequently the swivelling bearing II. must suffer the conditions accruing therefrom, and is therefore better neglected in the estimate of the critical speed.

But I must take exception to Mr. Henderson's treatment of bearing I. This bearing is 9 diameters long, and, if I remember aright, the diagrams in Professor Dunkerley's paper indicate that the "fixing" bearings in his experiments were 10 to 12 diameters long. Again, with a simply supported end of average length the centre of support is, admittedly, not quite so far out as the centre of the bearing; but it is most certainly not at the inner edge. This idea, which is not uncommon, seems to arise from the readiness with which the supporting condition of a statically deflected shaft can be visualised. The problem of the rotating shaft is dynamical, however, and the question of support is one of the distribution of oil pressure. It is hardly credible that this can be concentrated close to the inner edge. While I state this argument against the assumption of the inner edge as the point of support in cases of free shafts, I submit that, in the particular case under discussion, bearing I. can hardly be looked upon as a mere support. With such a long bearing, the "slope" that can be freely allowed must be very small, and so, at a comparatively early period in the development of the "whirl," the journal will bear "cape and corner"—as Mr. Henderson has it. It should be needless to remark that when this condition arises, a fixing action has been called into being, and the full "whirl" will be postponed. Consequently the whirling speed will be earlier than for a completely-fixed end, but later than for a free end.

This is in agreement with the actual results. I have shown that with Mr. Henderson's conditions the value is 7100 revolutions per minute, and I consider this to be high if the shaft is free, since the real point of support will be within the bearing. With the end quite fixed, the theoretical value is about 10,500 revolutions per minute, while the observed value is in reality 8640 revolutions per minute.

I regret that I did not observe the value on slowing down, in order to test Mr. Henderson's idea of a reduction; but I may say that no such occurrence was noticed in connection with the larger turbine.

I am, Sir, yours faithfully,

Airdrie, March 14, 1916. WM. KERR.

THE TITLE OF ENGINEER IN AUSTRIA.—A movement is at present on foot in several countries to confine the "title" of engineer to those who really are entitled to it by having passed the examination at a technical high school. The Austrian Minister for Public Works has now decreed that the title of engineer cannot be registered in connection with firms, &c., unless the person in question has the proper qualification—the passing of the examinations at a technical high school. The argument is that the registration constitutes a kind of official acknowledgment.

COMMISSIONS IN THE ROYAL MARINES.—Twenty appointments as Probationary Second Lieutenant, Royal Marines, will be offered for competition at the examination for admission to the Royal Military College, Sandhurst, and the Royal Military Academy, Woolwich, commencing on June 27, 1916. Candidates must be between the ages of seventeen and nineteen on June 1, 1916, and their names must reach the Adjutant-General, Royal Marines, 35, Spring-gardens, London, S.W., before April 1. It should be understood that this notice refers only to permanent appointments in the Royal Marines, and is not applicable to the entry of officers for temporary service.

OUR RAILS ABROAD.—The exports of rails from the United Kingdom in February showed considerable weakness, having declined to 3905 tons, as compared with 14,877 tons in February, 1915, and 35,484 tons in February, 1914. There were no shipments of rails to the Argentine Republic in February. The colonial demand for rails in the first two months of the last three years was represented by the following figures:—

Colonial Group.	1916. Tons	1915. Tons	1914. Tons
South Africa	131	3,966	20,623
British India	4169	14,563	16,149
Australia	317	13,372	35,004
Canada	Nil	2	1

BELGIAN METALLURGY.—There has been, it is stated, a slight revival in Belgian metallurgical industry under German auspices. At the La Louvière blast-furnaces some 400 to 500 men are now working, except on Mondays, while at the Nicaise and Delcuve works about half the usual force is employed. Structural plant at Bouvy and the Gilson rolling-mills are fully employed, while the La Croyère rolling-mills, which had been idle since the war commenced, have been re-opened. The Thirian blast-furnaces are working uninterruptedly. The Haine St. Pierre blast-furnaces are working three days per week, but the Baume rolling-mills have been closed down. The Ougrée Marihaye, the Sambre and Moselle, and the Providence steel works are in operation upon a restricted scale. Most of the Belgian steel works are reported to have sustained considerable losses last year, even although they may have resumed operations in whole or in part.

THE BETHLEHEM STEEL CORPORATION.—Following closely the Midvale acquisition of the Cambria Steel Company (see page 239 *ante*) came a formal announcement on February 18, says the *Iron Age*, that the Pennsylvania Steel Company had passed to the Bethlehem Steel Company. The purchase price aggregates approximately 31,900,000 dols. This acquisition is the outcome of the determination reached by the Bethlehem Steel Company some time ago to add to its output Bessemer steel and other general steel products, such as bridges, frogs and switches, girder-rails, rail fittings, &c. The Pennsylvania Steel Company's plants admirably supplement those of the Bethlehem Company. That at Sparrow's Point gives it an establishment at the seaboard, which it has long desired for the development of its export trade. The purchase also brings with it favourable ore properties both in the States and in Cuba, and also important coal deposits. The acquisition by the Bethlehem Company of the Pennsylvania Company's properties means a total annual producing capacity of over 3,500,000 tons of ingots, and a total of 17 blast-furnaces.

THE LEFEBVRE AGRICULTURAL TRACTOR.

We illustrate on this and the opposite page an automobile tractor built by Mr. E. Lefebvre, Rue du Champ-des-Oiseaux, Rouen, and designed specially for agricultural purposes. It has a guiding-wheel in front and two driving-wheels in the rear; it contains, moreover, on each side an adherence-chain which can be thrown in gear or raised out of contact with the ground according to the draw-bar pull required. The chassis, marked *a* in Fig. 3, is built up of steel channel bars 100 mm. by 60 mm. (3¼ in. by 2⅜ in.) in section, carried on the two driving-wheels *b*, each 1 m. (39⅜ in.) in diameter, and on the front guiding disc-wheel *c*, the diameter of which is 760 mm. (29¾ in.). The motor has four cylinders 120 mm. (4¾ in.) in diameter with a 160 mm. (6¼-in.) stroke, and develops from 35 to 40 horse-power at a speed of 900 revolutions per minute. It drives the tractor through the gear shown in Figs. 3 to 9, in which the references are the following:—

d. Driving-shaft.
e. Sprocket-wheel shaft
*e*¹. Sprocket-wheel.
f. Differential shafts.
g. Driving-chain pinion.
*g*¹. Driving-chain.

When the adherence chains are raised the tractor is comparable to an automobile of the usual type. The chain device is always raised when the tractor travels on the road. When it is desired to increase the tractive effort for ploughing on heavy ground, the adherence-chains are lowered, as illustrated in Figs. 2 and 3. By reference to this latter illustration, which shows the tractor in side elevation, also to the plan, Fig. 4, and to the detail parts, Figs. 5 to 9, it will be seen that the device consists of the following:—

h. Toothed pinion.
*h*¹. Driving-chain.
i. Sprocket-wheel
j. Countershaft for operating the adherence chain.
*j*¹. Clutch on countershaft *j*.
k and *m*. Adherence-chain sprocket-wheels.
l. Sheet-steel spades on the adherence-chains.
n. Frame of adherence-chain.
o. Adherence-chain guide and tension-pinion.

The adherence chains, unlike what obtains with the "caterpillar" device in tractors of other types, do nor carry the weight of the tractor, or carry but a very small proportion of this weight. They act as an adjunct to the driving-wheels. Their linear speed is exactly the same as the peripheral speed of the driving-wheels, and about 40 per cent. of the tractive effort falls to the wheels, 60 per cent. being exerted by the adherence chains. There are twenty-six spades, measuring 5 in. by 9 in., on each chain.

The adherence chain is raised or lowered on both sides simultaneously in 15 seconds by a gear located in front of the driver, the gear consisting of a nut *p* at the front end of the frame-bar *n*, which travels up and down a screw *q*, this being revolved from the main shaft by the bevel gear-wheels *r*, *r*¹, and *s*, and the belt-pulleys *t* and *t*¹. Each screw *q* placed in front of the adherence frame is fitted with the bevel gears *r* and *r*¹, the right-hand one having a right-hand thread, and the left-hand one a left-hand thread. In some tractors there are three pulleys side by side, a fixed one between two loose ones. An open belt is fitted on one of these latter, and a crossed belt on the other, the two loose pulleys revolving therefore constantly in opposite directions. By shifting either belt on the central fixed pulley, the driver raises or lowers the adherence frame. In the tractor we illustrate, the raising or lowering of the adherence-chain frame is effected by shifting to the right or to the left the bevel pinions marked *s* in the plan, Fig. 4. When the tractor is running on roads, the clutch *j*¹ enables the adherence-chain system to be thrown out of gear, the tractor being propelled by its driving-wheels alone. The adherence chain is kept clean by means of the protective coverings *u*, *v*, and *v*¹ (Fig. 6).

The change-speed gear has two speeds, and is reversible; the lower speed is 3.6 km. (2.2 miles), and the higher 4.8 km. (3 miles) per hour. The tractor weighs about 4000 kg. (8800 lb.) in working order. The tractive effort is normally of 2000 kg. (4400 lb.) with the chains lowered when ploughing; it is therefore exactly half the weight of the machine. We are informed that in the course of recent tests carried out by the French Ministry of Agriculture, the Lefebvre tractor, when hauling a balance-plough for two furrows, was able to cut furrows 12 in. deep and 32 in. wide. With a six-furrow plough the depth was 6 in. over a width of 6 ft. 6 in.

The Lefebvre tractors work either with petrol or benzol; firing is by a high-tension magneto.

This 40-horse-power tractor is also built when required with two front guiding-wheels, mounted on an axle of the automobile type; the wheels are 750 mm. (29½ in.) in diameter and 250 mm. (9¾ in.) wide at the rim. The front axle is connected to the chassis by two long plate-springs, which allow the tractor to travel over ruts without risk of deforming the chassis. The back driving-wheels are 1.120 m. (44 in.) in diameter and 250 mm. (9¾ in.) in width at the rim; the rims are smooth, but can easily be provided with clamps to increase adherence when required.

THE LEFEBVRE AGRICULTURAL TRACTOR.

CONSTRUCTED BY MR. EDMOND LEFEBVRE, ENGINEER, ROUEN.

FIG. 1. TRACTOR WITH ADHERENCE CHAIN RAISED.

FIG. 2. TRACTOR WITH ADHERENCE CHAIN LOWERED FOR PLOUGHING.

THE GEARED-TURBINE PROPELLING MACHINERY OF THE S.S. "NORTHUMBERLAND."

We give on our two-page plate, and on page 256, the first instalment of a series of complete illustrations showing the geared-turbine propelling machinery of one of several vessels fitted by the Wallsend Slipway and Engineering Company, Limited. But we prefer to delay the complete description of the work until the further illustrations are before the reader. The particular installation described is that for the s.s. Northumberland, built by Messrs. Swan, Hunter and Wigham Richardson, Limited, of Wallsend-on-Tyne, for the Federal Steam Navigation Company, under the supervision of Messrs. William Esplen, Son, and Swainson, Limited, engineers and naval architects, of London and Liverpool. The turbine machinery is designed to develop 7700 shaft horse-power in ordinary service conditions, and 9600 shaft horse-power under trial conditions. Fig. 1, on the two-page plate, is an elevation showing generally the arrangement of the machinery and boilers, with the boiler uptakes, funnels, and ventilators. Fig. 2, page 256, is a section at frame 108, showing the arrangement of the two forward boilers, while Fig. 3 is a section at frame 90, showing the aftermost boilers. The forced-draught fans are indicated between the boiler and engine-rooms. Further illustrations, including the plan of the general arrangement and sections through the engine-room, to be published later, will help to a clearer understanding of the installation, and we hope then also to give further drawings of the turbines, so that we defer a detailed description.

LEEDS AND LIVERPOOL CANAL.—The Leeds and Liverpool Canal Company is enabled to report an increase of 264*l*. in the company's net revenue for the past half-year. The traffic receipts of the six months were 72,431*l*., or 521*l*. more than in the corresponding period of 1914. The working expenses were 60,435*l*., or 256*l*. more. The revenue of the company in the second halves of the last five years was:—1911, 60,155*l*.; 1912, 91,094*l*.; 1913, 67,251*l*.; 1914, 67,215*l*.; and 1915, 72,431*l*.

CEYLON WOOD-PULP.—Having regard to the uncertainty attending the export of wood-pulp from Scandinavia to Great Britain, experiments are in progress in Ceylon with a view to the exploitation of forest reserves in order to determine to what extent the various wood products, which have hitherto been imported into the island, can be secured locally. The experiments also include the manufacture of glacial acetic acid and by-products, such as acetone, creosote, &c., secured through the distillation of wood-spirit. Wood-pulp experiments have been initiated by the Colonial Government, and preparations have reached an advanced stage. Experiments are also being conducted with wood-pulp, alcohol, &c.

AMERICAN WAR EXPORTS.—The exports of explosives from the United States in November were valued at 32,197,274 dols., as compared with 1,427,507 dols. in November, 1914, when, from an American standpoint, the great European conflict was just beginning. The total of 32,197,274 dols., representing the exports for November last year, was made up as follows:—Cartridges, 1,737,673 dols.; dynamite, 233,630 dols.; gunpowder, 16,730,384 dols.; all other materials, 13,495,587 dols. Other American war exports in November compared as follows with the corresponding month of 1914:—Horses, 5,299,823 dols., against 5,034,353 dols.; automobiles, 6,628,814 dols., against 2,879,177 dols.; motor-cycles, 168,141 dols., against 19,051 dols.; aeroplanes, 298,706 dols., against 31,935 dols.; firearms, 1,197,768 dols., against 1,194,510 dols. barbed wire, 1,359,864 dols., against 844,136 dols.; and copper, 13,518,797 dols., against 6,443,298 dols.

THE LEFEBVRE AGRICULTURAL TRACTOR.

CONSTRUCTED BY MR. EDMOND LEFEBVRE, ENGINEER, ROUEN.

(*For Description, see opposite Page.*)

Fig. 3.

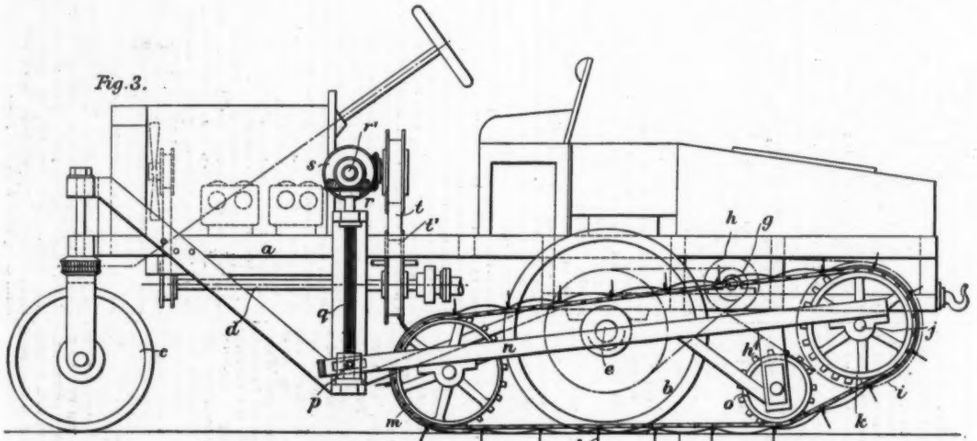


Fig. 4.

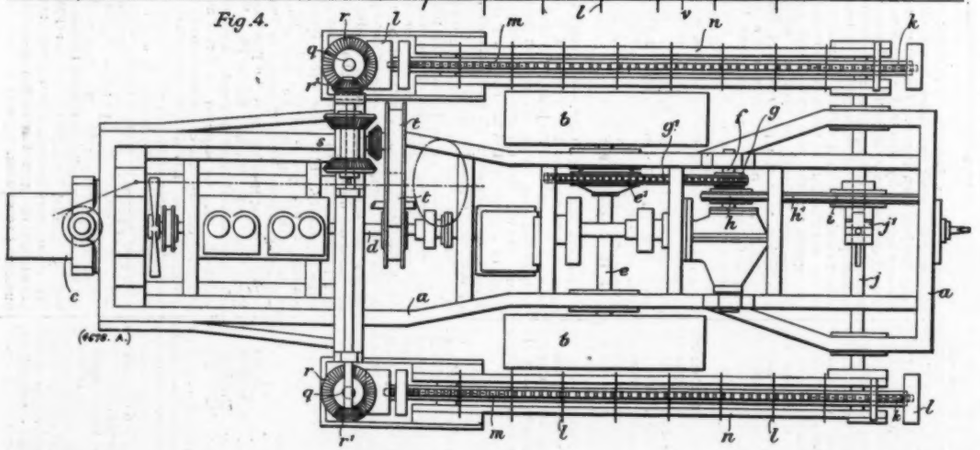
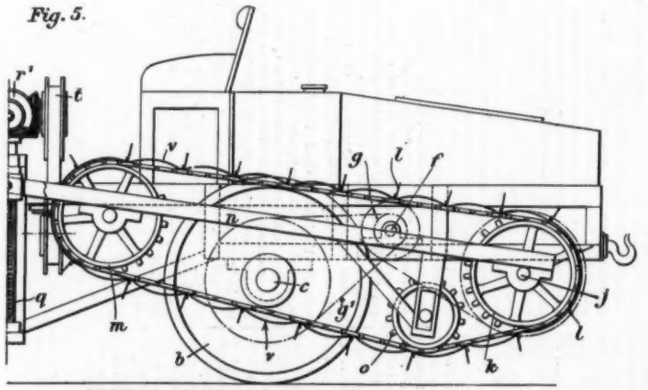


Fig. 5.



SHOWING ADHERANCE CHAIN RAISED

Fig. 6.

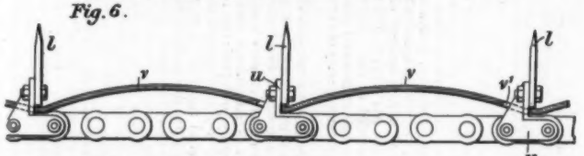


Fig. 7.

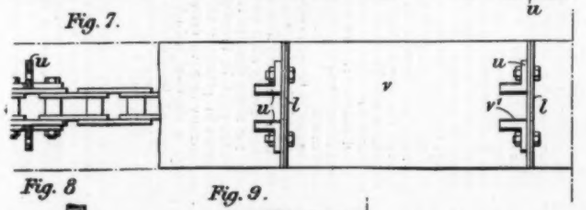


Fig. 8.

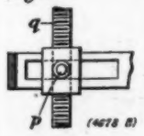
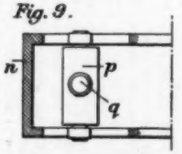


Fig. 9.



AMERICAN MACHINERY EXPORTS.—The exports of machinery from the United States last year were the heaviest on record, and the year closed with indications of great and continuous activity. There was, however, some falling-off in December in the shipment of steam-engines. The total value of the exports for the whole of 1915 was 134,128,862 dols., as compared with 91,818,664 dols. in 1914, and 127,980,680 dols. in 1913.

THE "FOKKER" AEROPLANE.—The current issue of *Le Génie Civil* gives an illustrated description of the "Fokker" monoplane, one of which, of the 1915 pattern, was captured by the French on their front. The "Fokker" machine, says our contemporary, contains no new feature; it is purely a counterfeit of the old Morane-Saulnier monoplane. The French journal reproduces a French monoplane of this latter type, built in 1913, side by side with the captured "Fokker" of the 1915 type, to illustrate its case. The "Fokker" machines are not the only German copies of French ones. The "Ago" monoplanes, built by the Aktien Gesellschaft Otto, were also copies of the Morane craft, but driven by a fixed instead of by a rotary engine; the Motorluftfahrzeug Gesellschaft had at the Vienna meeting in June, 1914, a machine which was the exact counterpart of the Morane-Saulnier "Parasol," the German company having had the ingenuity of continuing on its copy the same name "Parasol." The works which build the "Fokker" machines were, before the war, at Schwerin Görries (Mecklenburg); they have been transferred since, so it would appear, to Schweiningen. The first machine they built, in 1912-13, had no resemblance whatever to their present ones. It was only after having witnessed the success of the Morane-Saulnier aeroplanes that the German firm commenced building identical ones. As a general rule, German aviation has simply copied French methods and followed French progress. There are two "Fokker" monoplanes, having either one or two seats, and one biplane, which is also similar to the biplane of the same French builders. Our contemporary is therefore able to state that the "Fokker" machines are in no way superior to the French ones; the matter resolves itself into counterfeiting one of the French inventions, among which the enemy is always ready to make a selection, and he does so without any scruple.

THE LATE PROFESSOR ERNST MACH.—Professor Mach, whose death was reported from Vienna in the first days of March, was one of the first, if not the first, who succeeded in studying by means of photography, the waves which a bullet flying through the air sets up in its front and rear. He was born at Turas, Moravia, in 1838, studied in Vienna, and became university lecturer there in 1861. Having spent a few years at Graz as professor of mathematics, he was called to Prague as professor of physics in 1867, and remained there till 1895, when he returned to the University of Vienna. He was author of several physical text-books, in one of which Jaumann was his collaborator, and the mechanics of motion, especially also of living bodies, attracted his particular attention. His "Analyses of Sensations" and "Science of Mechanics" date from this period. His investigation of flying bullets was part of his optical-acoustical studies. With his breadth and depth of knowledge, Mach exercised a general and healthy influence at home and abroad upon current scientific views in his later years, when he devoted himself in his lectures and writings chiefly to the study of the history of physics.

GERMAN WAR PROFITS.

WHILST undoubtedly a large number of German industrial undertakings have suffered, and are suffering, very seriously from the war, not a few are making very handsome war profits. The most striking example, so far, is the Gas Apparatus and Gas Works Company in Mayence, a small concern, with a share capital of only 1,080,000 marks, but which for 1915 has earned net profits of 3,636,547 marks, against 33,985 marks previously. The shareholders receive a dividend of 125 per cent., and 1,800,000 marks are reserved for war profit taxation. Writings-off, &c, are naturally amply provided for. It is notable that the bulk of the profits has been invested in the war loans—viz., as much as 2,879,661 marks.

The Rhenish Metal Goods and Machine Company has also made vastly increased profits for 1915, thanks to energetic working on war orders, although shortage of hands, difficulties of transport, &c., have impeded the manufacture, and although wages have risen materially. Thus the average wage per man and shift for 1914-15 comes out at 5.80 marks, against 5.22 marks for the preceding year, the figures also comprising juvenile and female hands (4833). That the degree of employment is still on the increase will appear from the fact that, in spite of the existing general shortage of hands, the number employed has risen from an average of 14,414 hands in 1914-15 to about 24,000 at the present time. The net profits amounted to 9,876,619 marks, against 3,524,439 marks for the preceding year. The preference shares obtain a dividend of 13 per cent., and 11 per cent. goes to the ordinary shareholders; the sum paid in dividends this year falls somewhat short of that paid for the preceding year, when some old deficits in the way of dividends were wiped off. About 2,000,000 marks were applied to the redemption of profit vouchers and other obligations. A sum of 5,300,000 marks was reserved for war profit taxation. The value of securities held by the company has risen from 57,316 marks to 2,605,876 marks, principally on account of war loan investments.

The Rheydt Electrotechnical Company, thanks to military contracts, has quintupled its turnover in 1915, compared with the previous year. In addition the so-called still reserves have been swelled by certain assets remaining booked at very low figures; the report calls this "a mobilisation of the still reserves accumulated in past years," and evidently hopes that they can thus be protected from war profits taxation, a view which has been questioned in the Press. The profits for 1915 amount to 3,580,592 marks, against 385,635 marks for 1914; the shareholders obtain a dividend of 20 per cent., against 12 per cent. for 1914, a sum of 1,850,000 marks is reserved for war profit taxation, war aid, &c., and 875,000 marks are used in increasing the share capital by the granting of free shares. The company has subscribed 2,500,000 marks to the war loan.

The Hirsch Copper and Brass Works, which pay a dividend of 18 per cent. for 1915, against 8 per cent. for the three preceding years, has in addition, by writing off 1,490,539 marks, reduced the booked value of the machinery account to 2 marks, which is accounted for by the extraordinary wear and tear resulting from, and the various alterations necessitated by, the special and highly-accelerated work for the army. The company, although very hard pressed, had been able to effect deliveries in due time and was also fully prepared to face the calls made upon them for the new year.

The Rhenish Tannery Goods Company, of Benrath, pays 25 per cent. for last year, against 16 per cent. for the preceding year, the surplus being 560,757 marks, against 346,789 marks for the previous year. The company had succeeded in utilising inland tannery materials with good results. A sum of 150,000 marks for a special war reserve fund, and another sum of 200,000 marks for war profit taxation, had been previously deducted, and do not appear in the surplus, the reason stated being the necessity of counterbalancing the heavy wear and tear of the plant. It looks as if the war-profit taxation authorities will have a good many items to investigate in the different balance-sheets of German industrial undertakings.

THE WORLD'S GOLD.—The world's production of gold last year, according to American statistics, was 470,979,890 dols., the aggregate being made up as follows:—Africa, 217,671,392 dols.; North America, 137,491,100 dols.; Europe, 29,650,000 dols.; Asia, 28,094,385 dols.; South America, 13,750,000 dols.; and Australasia, 44,000,000 odd dols. The gold output of 470,979,890 dols. attained last year compares thus with the corresponding production from 1906 to 1914:—

Year.	Value. dols.	Year.	Value. dols.
1906	405,551,022	1911	459,377,300
1907	411,294,458	1912	474,333,268
1908	443,434,527	1913	462,069,658
1909	459,927,482	1914	461,582,129
1910	454,213,649	1915	470,979,890

It will be seen that the world's gold output is still increasing, although only a small advance has been made during the last five years. The expansion which has taken place is attributable, of course, to increased attention to the gold-mining industry. The yield of gold advanced last year in Africa, North America, and South America; but it decreased, although not to any material extent, in Europe, Asia, and Australasia. The principal gold-producing countries continue to be the Transvaal, the United States, Australasia, and Russia. The Transvaal produced last year about 40 per cent. of the world's output; the United States, 21 per cent.; Australasia, 9 per cent.; and Russia, 6 per cent.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, March 1.

THE past week has been quite active in steel rails and steel cars; several roads have placed fairly sized orders, and the necessity for rolling-stock is bringing out quite large orders for roads in various parts of the country. The organisation of the sugar industry in Cuba has opened up possibilities for standard and narrow-gauge railroad trackage, which means much for that country. The general steel situation is extremely acute; the entire producing capacities for the current year could be sold up at once if orders pending and waiting were accepted. What the volume of unplaced munition business is there is no means of knowing. Railroads are also pushing forward bridge-building, but it is very difficult to place orders for steel plate excepting for late delivery; prices continue to move up, not through any efforts of manufacturers, but through the competition of buyers against each other. Premiums are offered all the way from 5 dols. to 25 dols. for plates for what is regarded as early delivery. The United States are now producing iron and steel equal to about three times the combined capacity of Great Britain and France.

It begins to be more clearly apparent that the pivot as to the war's duration will depend more upon a supply of steel than of human flesh and blood. Steel mills are looking more clearly after domestic demands than they have been for some time, as it is recognised that industrial activities must be thoroughly protected; the remarkable advances in prices of all products stimulates inquiries and anxiety to have material ready when wanted. The future of the steel industry in this country is uncertain as measured by ability to meet oncoming demands; the limit of pig-iron production seems to have been reached. Rumours prevail to-day of new inquiries for munition supplies, and their acceptance on satisfactory terms as to dates of delivery seems remote. All old low-price steel contracts have been practically filled, and the orders now being worked upon will bring big margins and result in a general activity in steel stocks. General construction would be more active if structural material could be had cheaper.

FRENCH COAL.—France's production of coal in 1913 was 41,000,000 tons; the following year the output receded to 30,000,000 tons, and as the territory occupied by the enemy yields about three-fourths of the country's aggregate production of coal, the figure for 1915 can hardly be put at more than 10,000,000 tons.

THE SHIPPING WORLD YEAR-BOOK.—The thirtieth edition of this work, invaluable to all interested in shipping, has just been issued. The chaos consequent upon the war necessarily involved a much increased amount of work on the editor, Major E. R. Jones, but we have no doubt that that high degree of accuracy which has characterised preceding editions will have been exercised in order to make the book as reliable as is possible. Many of the details—for instance, the complete shipbuilding figures for the year and official trade and other returns—are lacking, so that the editor has had to be satisfied with the publication of the latest figures available. The port directories are brought up to date, so far as this country is concerned, but those of the enemy and, in most cases, of Allies, have had to be left unrevised. As far as possible, also, the tariffs of all the nations have been brought up to date, involving quite an extensive revision. The book is published from the *Shipping World* Offices, Effingham House, Arundel-street, London, W.C., at 10s. net for the United Kingdom, and 11s. net for other countries. It includes a revised map of the world, specially prepared by Mr. J. G. Bartholomew, F.R.G.S.

THE LATE MR. F. T. JANE.—We regret to have to place on record the death of Mr. Frederick T. Jane, the well-known writer on naval subjects. He died somewhat suddenly at Southsea, on the 8th inst., at the age of forty-six years. He was the eldest son of the Rev. John Jane, Vicar of Upottery, Devon, and early in life began to develop an interest in all naval matters, first devising a game for the practice of war tactics. In 1898 he published the first issue of his annual on "Fighting Ships," which was based on some of the principles of the game, the fighting qualities of the ships being classified. The feature of the annual was the silhouettes, which enabled anyone to distinguish, at a distance, by the mast, funnels, and other "sky-signs," the class, if not the exact ship and nationality. In 1910 he produced the first edition of "The World's Air-Crafts," and both publications have continued and acquired a large popularity. Mr. Jane wrote largely also for our contemporaries, the *Engineer* and the *Standard*, and is the author of quite a number of books on naval subjects, including "The Torpedo in Peace and War," "The Imperial Russian Navy," "The Imperial Japanese Navy," and "The British Battle Fleet." His writings generally lacked that intimate technical knowledge which can only be acquired by direct association with either the construction or management of ships, and consequently he was not always quite reliable in the deductions made. But there can be no doubt of the influence he exercised on the rapid growth of public opinion and general sympathy with naval affairs, which has simplified the task of those responsible for the maintenance of the Fleet, since it has enabled higher votes to be supported by the will of the people. Mr. Jane, with the same end in view, unsuccessfully contested Portsmouth in 1906 as "Navy interest" candidate, but our Party system, on this as on many occasions, prevented a man with special knowledge of special interests gaining the necessary number of votes when opposed by Party candidates.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—The returns for the month of February show a pronounced falling-off in the amount of coal traffic from the South Yorkshire collieries to Hull. The imports from the collieries to the port were 265,063 tons, or 57,000 tons less than in the same period of the preceding year. The total of 539,185 tons for the months of January and February of the present year is approximately no less than 160,000 tons below the figures of the two months of 1915. A similar condition of affairs prevailed with regard to the export business. The total was 84,516 tons, or a weekly average of 21,000 tons, against a weekly average of 34,000 tons for February of last year. The export for the present year up to date is 210,885 tons—a decrease of 145,000 tons on the corresponding figure for 1915. Altogether, traffic in the present year is about 50 per cent. below that of normal times. Three-quarters of the total export has gone to France; but the February exports both to France and to Sweden were a marked reduction on last year. On the other hand, the coal sent to Holland was an increase of about 7000 tons.

South Yorkshire Coal Trade.—The position has not improved on last week, and the outlook, especially with regard to house coal, is assuming a rather serious aspect. Coal merchants report that what small stocks of house fuel were held are now practically depleted, and with irregular workings at the pits and delays in conveying the coal on the railways, the problem of meeting all demands does not lend itself to a simple solution. A concrete instance is afforded by the experience of a large Sheffield firm. Supplies of best house quality have been "on the road" twenty days, and yet the total distance on the main railway line is not more than a score of miles. In face of such a service, merchants are unable to promise delivery for fixed dates. The situation with regard to steam and hard grades shows little change. Home works are evidently just able to secure sufficient to keep running, but some have had to resort to the practice of depleting their small reserve stock at one establishment to enable another branch to "carry on." The tonnage for shipment averages about the same for Allied countries; whilst, on the neutral account, Swedish inquiries are persistent. For delivery at Gothenburg, Swedish steel-makers are prepared to pay 3*l.* to 3*l.* 2*s.* per ton. The Board of Trade licensing scheme, however, comes into operation in this connection and the supplies to Scandinavian countries are consequently only of a limited character. The freightage, Hull to Gothenburg, is round about 32*s.*, leaving the ample margin of 30*s.* for the seller. Gas fuels are a ready market for inland works. The slack and coke markets are very firm, with top figures easily maintained. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire best brights, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire house, 16*s.* to 17*s.*; best large nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; small nuts, 15*s.* to 16*s.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 8*s.* to 9*s.*

Iron and Steel.—The market remains unchanged. The demand is still abnormally heavy, and consequently makers are able to obtain the Government maxima of prices for all grades. Considerable business has been done in Derbyshire foundry and forge irons, but in the case of Lincolnshire brands makers are not seeking orders, as the commodity is sold as soon as it is manufactured. Hematites maintain the easier tone of last week, with East Coast 140*s.* on truck and West Coast quite 10*s.* below this figure. The question of the supply of billets, blooms, and slabs is still giving rise to much anxiety. Last month only 13,203 tons of billets were imported, or about 33.3 per cent. less than the figures for the corresponding period of 1914. Added to this is the increased exportation of billets, &c., from here to France and others of our Allies. The Swedish-steel-makers are disinclined to sell any large quantities because of the drastic operation of the coal-export licences against their country. They are, nevertheless, eager to bargain, and would undoubtedly increase the supply of billets if they could obtain Yorkshire coal in return. At the present there is no likelihood of such an arrangement being arrived at, and the consequent falling-off in the supply of Swedish billets has given prices a sharp upward tendency. Swedish quality is now about 32*l.* per ton with delivery in Sheffield. It is reported that 10,000 additional workmen are to be employed on the new extensions of the large munition works. Serbian artisans are the latest arrivals, and the cosmopolitan nature of the Sheffield workers can be gleaned from the statement that Belgians, Dutchmen, Danes, Canadians, Americans, and Serbians are now in the ranks. Some idea can be gathered of the probable effect of the new drink regulations put into force in Sheffield. It is asserted by certain manufacturers that the loss of time is reduced enormously, and the output has been much improved in consequence. Two more firms have taken up the manufacture of "Stainless" steel, which is enjoying an increasing popularity. New War Office orders are for 200,000 saws, hack-saws, &c., and 120,000 knives, including various types of carvers, cooks', table, bread, and butchers' flaying-knives. There is a brisk tone in the oversea business, with large demands for steel, tools, cutlery, and electro-plate.

CHARCOAL IN SWEDEN.—The transport of charcoal in Sweden presents quite a small problem to the State Railways during the period from January to April, when it goes on. This year not less than about 25,000 wagon loads have to be dealt with, an increase of about 40 per cent. compared with last year.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—As on the two previous days, dead idleness prevailed in the pig-iron warrant market last Thursday morning, cash sellers' prices remaining nominal at 86s. 9d. per ton. In the afternoon, however, 2000 tons changed hands at 82s. 6d. cash, while a private deal of 500 tons was reported on forward account, for which 86s. 3d. was realised. At the close cash sellers' figure was still quoted at the forenoon's level. On Friday forenoon one Cleveland warrant was dealt in at 86s. 6d. cash, sellers quoting at the close 86s. 5d. per ton cash, with the settlement price 86s. A nominal advance to 86s. 9d. cash sellers marked the only change at the afternoon's session. Monday's market still continued unsatisfactory, no business being done at either session. In the morning cash sellers were quoted 87s. 6d., while no change took place in the afternoon. The only transaction recorded yesterday morning was one of 1000 tons, which realised 87s. cash, while in the afternoon no business whatever was done. Complete idleness ruled again this morning, when cash sellers quoted 88s. 9d. per ton for Cleveland warrants.

Sulphate of Ammonia.—The demand for sulphate of ammonia as a fertiliser keeps steady, and although consumers are rather inclined to grumble at the increased cost, they are fully alive to its value, realising that at the present time its use is of supreme national importance. For prompt delivery at Glasgow the current rate is about 17*l.* 10s. per ton.

Scotch Steel Trade.—Little change has taken place in the local steel trade during the past week; it is still a tale of ceaseless activity, strong prices, much pressure and uncertain delivery. Sectional material, particularly on Government account, is greatly in demand, while France is a constant and steady customer, large orders being booked almost daily. Indeed, the export trade generally, including Colonial inquiries, is keeping all the works going, the main difficulty being, not scarcity of orders, but the dearth of workmen and the high cost of freight. Meantime, however some considerable uncertainty prevails in connection with the maximum rates which Government proposes to fix. If the arrangements were definitely settled, makers would feel in a more assured position, for there might then be some chance of a better supply of raw material being available, which would doubtless add to the already enormous output. If the war is to be brought to a satisfactory termination in anything like a reasonable time, every possible effort must be made to keep up and increase the manufacture and output of munitions and other war material. Mercantile business is therefore at a complete standstill, the difficulties of negotiating orders of this nature being constantly on the increase, as every order booked must first be submitted to the Ministry of Munitions. On account of this orders are being refused every day, as makers are totally unable to undertake other than the Government and Admiralty contracts. Prices continue strong, boiler-plates being quoted at 14*l.* 10s. per ton; ship-plates, 13*l.* to 13*l.* 10s.; and angles, 13*l.* 10s. to 13*l.* 15s.—all less the usual 2½ per cent.

Malleable-Iron Trade.—In the malleable-iron trade the continued pressure for delivery is the most outstanding feature, and the greatest activity prevails. While Government contracts take first place, malleable-iron makers are at liberty to accept more mercantile business than the steel-makers can, as there is not the same demand for iron as for steel in the manufacture of munitions. So far, the malleable-iron trade has not come under any Government restrictions, which gives the makers a freer hand than they otherwise would have. "Crown" bars may be 13*l.* 10s. per ton, or more, less 5 per cent. discount for prompt delivery, while for net export they may be had for 13*l.* 7s. 6d.

Scotch Pig-Iron Trade.—The order restricting speculative dealings in Scotch pig-iron is already constituting a considerable scarcity both in makers' No. 1 iron and in hematite. Hematite, however, is in exceptional demand, and although Government has fixed the maximum price for home consumption at 6*l.* 2s. 6d. per ton, the current rate still remains at 7*l.* 2s. 6d. to 7*l.* 5s., or thereabouts, sellers offering supplies at these figures. For ordinary qualities prices keep firm, and foundry iron is in much better demand than it was, while rumour has it that, as in the case of hematite, its export will shortly be considerably restricted. All over, makers are in quite a strong position. The current quotations for makers' (No. 1) iron are as follow:—Langloan, 122s. 6d. per ton; Summerlee, 125s.; Clyde, Calder, and Gartsherrie, 127s. 6d. (all shipped at Glasgow); Eglinton and Glengarnock, 120s. (both at Ardrossan); Dalmellington, 112s. 6d. (at Ayr), and Shotts, 127s. 6d. (at Leith).

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron is becoming more and more scarce, and there is a prevailing opinion that export to neutral countries will be prohibited in the near future. Demand from abroad is heavy, and so keen are Scandinavian customers to obtain supplies that many of them have instructed merchants here to make contracts on the best terms possible. Merchants now quote No. 3 Cleveland pig-iron at 89s. 6d. f.o.b. for export, and ask about 4s. to 5s. above that figure for No. 1, whilst they put No. 4 foundry at 88s. 6d. Makers are in no hurry to sell, and as a rule ask a little above the foregoing quotations. There is practically no Cleveland pig-iron available for sale to home consumers for early delivery, and fears are entertained that the shortage may soon be seriously felt. Quotations for home use remained nominally at the fixed maximum of 82s. 6d. for No. 3, No. 4 foundry, and No. 4 forge.

Hematite Iron.—Very little new is ascertainable concerning the hematite branch of the staple industry. There is no iron on offer for supply until after June, and many makers have committed themselves as heavily as they care to for the present. For home consumption the maximum of 122s. 6d. for Nos. 1, 2, and 3, fixed some little time ago, still rules, and the export price remains at 140s.

Shipments and Stocks of Pig-Iron.—Shipments of pig-iron from the port of Middlesbrough are quite up to expectation. So far this month they average 1891 tons per working day, the total despatches reaching 24,587 tons, as compared with total loadings of 23,150 tons, or a daily average of 1781 tons to the same date last month, and clearances of only 4185 tons, or an average of 322 tons per working day for the corresponding part of March last year. To meet current needs stocks of pig-iron are being steadily drawn upon. Makers now have little or no iron lying at their yards, and practically the only stock is the pig in the public warrant stores, which is this month being reduced at the rate of 1000 tons per working day. The quantity of Cleveland pig-iron held in the warrant stores stands at 70,371 tons, of which 67,843 tons are No. 3 quality, and 2528 tons other kinds of iron deliverable as standard. So far this month 12,563 tons of No. 3 and 257 tons of standard iron, making a total of 12,820 tons, have been withdrawn from the stores.

Coke.—Demand for coke for local use keeps on a good scale, and further business is reported at the fixed maximums for home consumption of 28s. at the ovens for average blast-furnace kinds, and up to 30s. 6d. at the ovens for qualities low in phosphorus.

Foreign Ore.—Notwithstanding the continued absence of business, foreign ore quotations are fully maintained. Consumers are very well placed, having fairly large stocks and very considerable supplies steadily coming in on contracts. Market rates are based on quite 42s. 6d. ex-ship Tees for Rubio of 50 per cent. quality. Freights Bilbao-Middlesbrough are stiff, at 26s. 6d. Imports of foreign ore to the Tees to date this month amount to 47,801 tons.

Output of Limestone.—Owing to the anxious desire of the limestone-quarry owners to increase the output, a conference was held this week of the employers and representatives of the Cleveland Miners and Quarrymen's Association, at which it was explained that owing to the weather and the shortage of labour it had been found necessary to make depletions in the general emergency stock which was kept at the mines for such purposes as had now arisen, and in order that the depletions be made up, the employers suggested that the men work overtime. Ultimately the suggestion was agreed to, time men to receive overtime pay at the rate of time and a half, and piece-workers to receive 6d. extra per hour for overtime. No suggestion of Sunday work was made.

Manufactured Iron and Steel.—In the finished iron and steel industries numerous private inquiries are reported, but they result in little or no business, manufacturers being still too busily engaged on Government work to pay much attention to ordinary commercial business. Prices all round are strong. The following are among the principal market quotations:—Common iron bars, 13*l.* 10s.; best bars, 13*l.* 17s. 6d.; best best bars, 14*l.* 5s.; packing iron (parallel), 10*l.*; packing iron (tapered), 11*l.* 15s.; iron ship-plates, 11*l.* 10s.; iron ship-angles, 13*l.* 10s.; iron ship-rivets, 16*l.*; steel ship-plates 11*l.* 10s.; steel ship-angles, 11*l.* 2s. 6d.; steel strip, 13*l.* 10s.; steel hoops, 14*l.*; steel joists, 11*l.* 2s. 6d.; and heavy steel rails, 10*l.* 17s. 6d.—rails net f.o.b., steel ship-building material net at works, and all other descriptions less 2½ per cent. discount.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The situation in steam coal is still difficult. Collieries producing superior qualities reserved by the authorities are still able to work regularly, but other sellers have experienced great difficulty in clearing wagons quickly enough to avoid pit stoppages. Recent discussions have dealt with the probable course of coal-trimmers and other labour organisations with respect to Government proposals for continuing the loading of vessels on Saturday afternoons in order to reduce or obviate week-end delays. Shipowners are endeavouring to fix freights for French ports as a preliminary to a general control of freights. The best Admiralty large steam coal has been, to some extent, nominal; the best secondary qualities have made 30s. to 31s.; best bunker smalls, 16s. to 17s.; and cargo smalls, 10s. to 12s. per ton. Quotations for household coal are returned as follow:—Best households, 23s. to 24s.; good households, 21s. to 22s.; No. 3 Rhondda large, 30s. to 32s.; smalls, 21s. 6d. to 23s. 6d.; No. 2 Rhondda large, 26s. to 27s.; and No. 2 smalls, 15s. 6d. to 16s. 6d. per ton. The latest quotation for patent fuel has been 35s. to 36s. per ton. Special foundry coke has made 50s. to 52s. 6d.; good foundry coke, 47s. 6d. to 50s.; and furnace coke, 35s. to 40s. per ton. As regards iron ore, Rubio has made 39s. to 40s. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Western Trade Matters.—The Bury Port and Gwendraeth Valley Railway Company has declared a dividend of 10 per cent. upon its ordinary shares for 1915. Sir T. Pilkington, who presided at the annual meeting, stated that two of the directors were at present on active service in France. Sir T. Pilkington also stated that the working expenses had been reduced during the past year to the extent of some 2000*l.*, notwithstanding the difficulties incident to a great war; as a result of this, a larger allocation had been made to the reserve.—There has been a further advance in freight rates at Cardiff, and the cost of South Wales coal delivered in Italy is about 6*l.* per ton; at Marseilles, it costs something over 5*l.* per ton; and at Gibraltar and Oporto, 4*l.* per ton.—At the annual meeting of the Celtic Collieries, Limited, the chairman (Sir Owen Philipps) stated that the company's property has a mineral area of about 1400 acres, containing not less than ten workable seams of coal. The chairman added that large sums had been expended from time to time in equipping the collieries with up-to-date appliances for screening and washing coal, and the plant was reported to be in good condition. A dividend of 10 per cent. was announced for 1915, and it was intimated that the excess profits tax would be about 9000*l.* for the past twelve months. A controlling interest in the Celtic Company having been acquired by new investors, the present directors have retired from office.—Mr. E. L. Evan-Thomas presided at the annual meeting of North's Navigation Collieries, 1889, Limited, and stated that the net profits of the undertaking for 1915 had been 130,071*l.*, admitting of an ordinary dividend and bonus of 12½ per cent. for the year, 35,000*l.* being added to the reserve (to provide for the excess profits), 15,000*l.* being written off for depreciation, and 10,567*l.* being carried forward. The chairman added that he considered this a satisfactory result, having regard to the upward tendency of wages and the rise in the price of all materials and in winning coal.—In connection with the recent transfer of shares in the Barry Graving Dock and Engineering Company, Limited, to the Cardiff Channel Dry Docks and Pontoon Company, Limited, two directors of the Barry Company have retired, their places being taken by Mr. J. Cory and Mr. Radcliffe; it is considered that two other changes in the directorate will follow shortly.—Mr. Lewis E. Turnbull occupied the chair at the annual meeting of the Penarth Pontoon, Slipway, and Ship-Repairing Company, Limited, and stated that the year's profits amounted to 14,501*l.*; a dividend of 6 per cent. was declared, 3000*l.* was added to the reserve, and 4351*l.* was carried forward; 2450*l.* was expended out of revenue last year in overhauling the pontoon, slipway, jetties, and piers.—The general manager of Swansea Harbour reports a decline in the trade movement of 213,180 tons for 1915, the imports accounting for 196,841 tons, and the exports for 18,339 tons. The exports of coal and patent fuel to France increased about 1,000,000 tons; but, taking the aggregate shipment of these articles into account, the increase was only 15,000 tons. The shipments of tin, terne, and black plates fell 39,000 tons, and galvanised wire shipments also fell 36,000 tons; steel, however, increased 24,000 tons.—Owing to facilities afforded in the King's Dock for bunkering large vessels, there has been a gratifying increase in the number of steamers calling for that purpose.—The total trade movement of Swansea for 1915 amounted to 5,876,477 tons, against 6,091,657 tons in 1914. The total imports for last year were nearly 870,000 tons, and the total exports were over 5,000,000 tons.—The directors of the Plynlyber Navigation Colliery Company, Limited, recommend a dividend of 12½ per cent. for the ordinary shares for the past year, 21,405*l.* being carried forward. The balance available for dividend for 1915, including 22,855*l.* brought forward, was 81,692*l.*—Mr. Hedley Clark has been appointed general manager of the collieries composing Consolidated Cambrian, Limited; Mr. Clark has for some time been associated with the undertaking, and in future he will have the control also at Gilfach Goch.—The Bristol City Council will have to advance 83,000*l.* to finance Bristol docks for 1915-16; this is not satisfactory, but the amount is 14,000*l.* less than the corresponding advance of 1914-15.—The profit realised by the United National Collieries, Limited, in 1915, was 299,520*l.*, after providing for excess profit duty, and a dividend of 25 per cent. is to be paid for the twelve months. The profits of the last five years have been:—1911, 93,183*l.*; 1912, 86,030*l.*; 1913, 119,152*l.*; 1914, 169,048*l.*; 1915, 299,520*l.* Last year's profits were considerably increased by the acquisition of the Bute Merthyr collieries.

EXHIBITION OF GERMAN CATALOGUES IN LONDON.—In order that British manufacturers may have an opportunity of familiarising themselves with German methods of publicity, the Board of Trade have collected over 3000 specimen catalogues of German origin, and these may be inspected at the Foreign Samples Section of the Commercial Intelligence Branch, 32, Cheapside, London, E.C. The collection, which is illustrative of a great variety of industries, includes 887 catalogues of machinery. Recent additions have brought the number of catalogues of toys up to 271, including the productions of most of the well-known Nuremberg toy manufacturers, and in view of the progress made by British toy manufacturers, these catalogues should prove of particular interest to firms engaged in the industry. There are also 177 catalogues of fancy goods and 71 of glassware. One feature of the catalogues which is of special interest to British manufacturers who are themselves publishing catalogues with a view to increasing their export trade, is the number of foreign languages in which the German catalogues are printed. The Board of Trade collection includes catalogues printed in English, French, Spanish, Portuguese, Roumanian, Russian, Finnish, Polish, Italian, Dutch, Hungarian, and Greek. Many are polyglot in character, and are printed in three, four, and in some cases five different languages. Arrangements have been made whereby catalogues may be lent for a few days to United Kingdom firms established in the provinces.

ARRANGEMENT OF BOILERS IN THE FEDERAL LINER "NORTHUMBERLAND."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Notice, see Page* 252.)

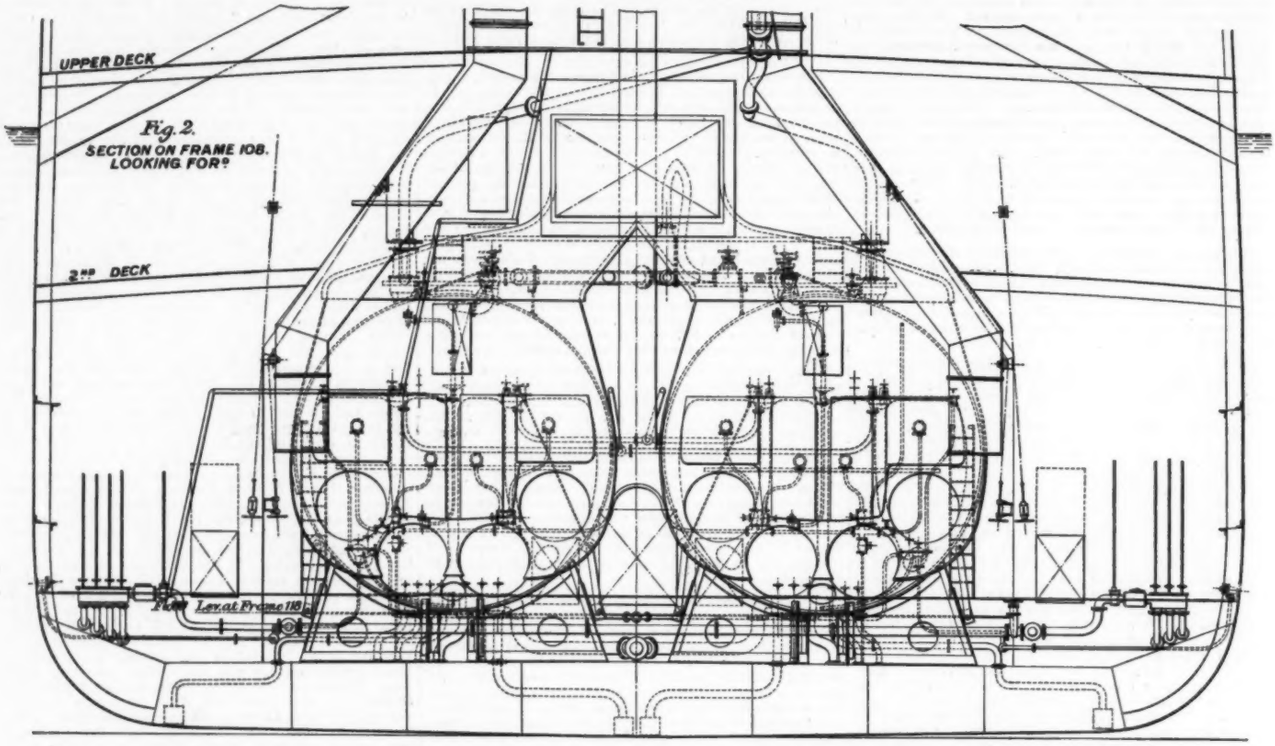


Fig. 2. SECTION ON FRAME 108. LOOKING FOR'D

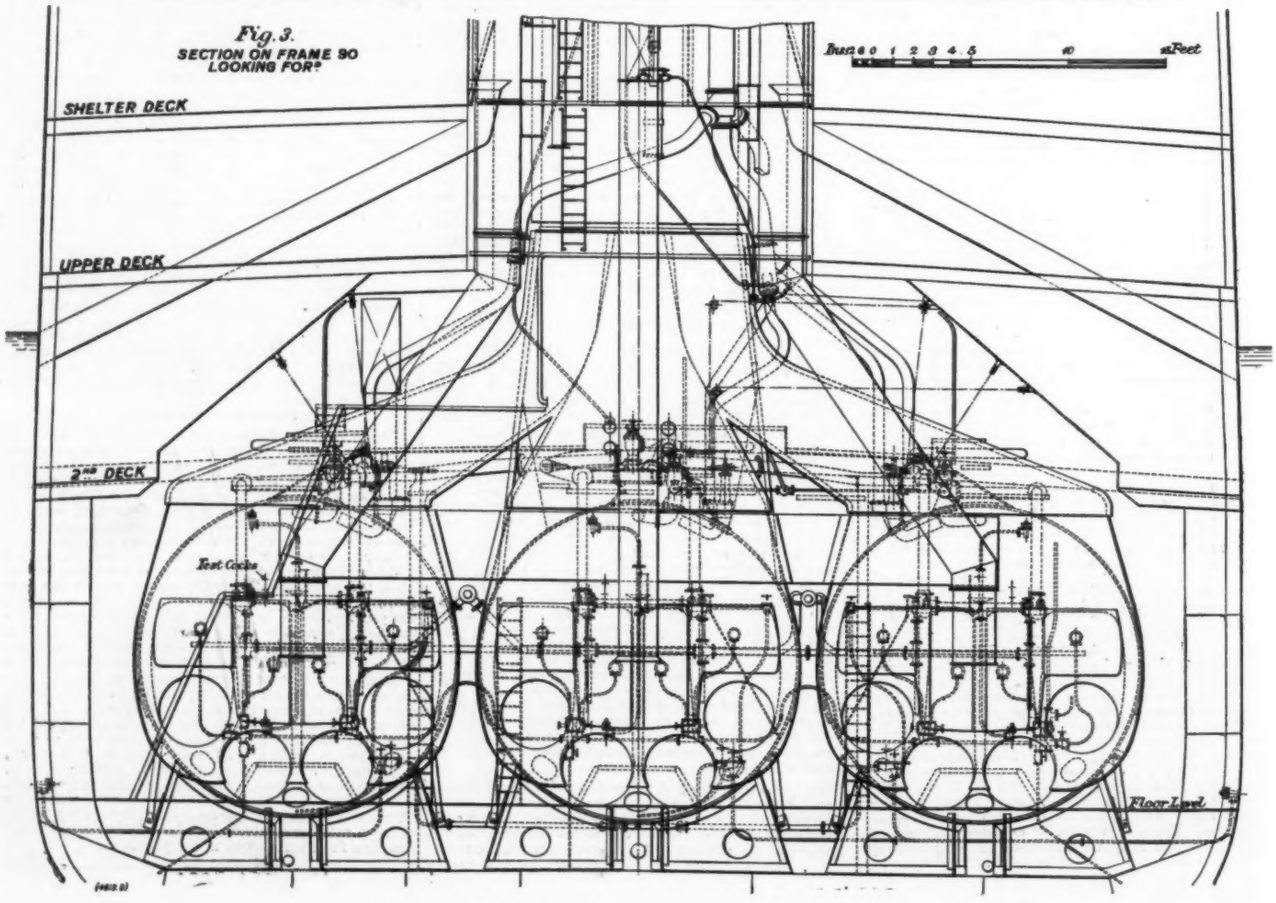


Fig. 3. SECTION ON FRAME 90 LOOKING FOR'D

GENERAL ARRANGEMENT OF THE GEARED-TURBINE PROPELL

CONSTRUCTED BY THE WALLSEND SLIPWAY AN ENGINE

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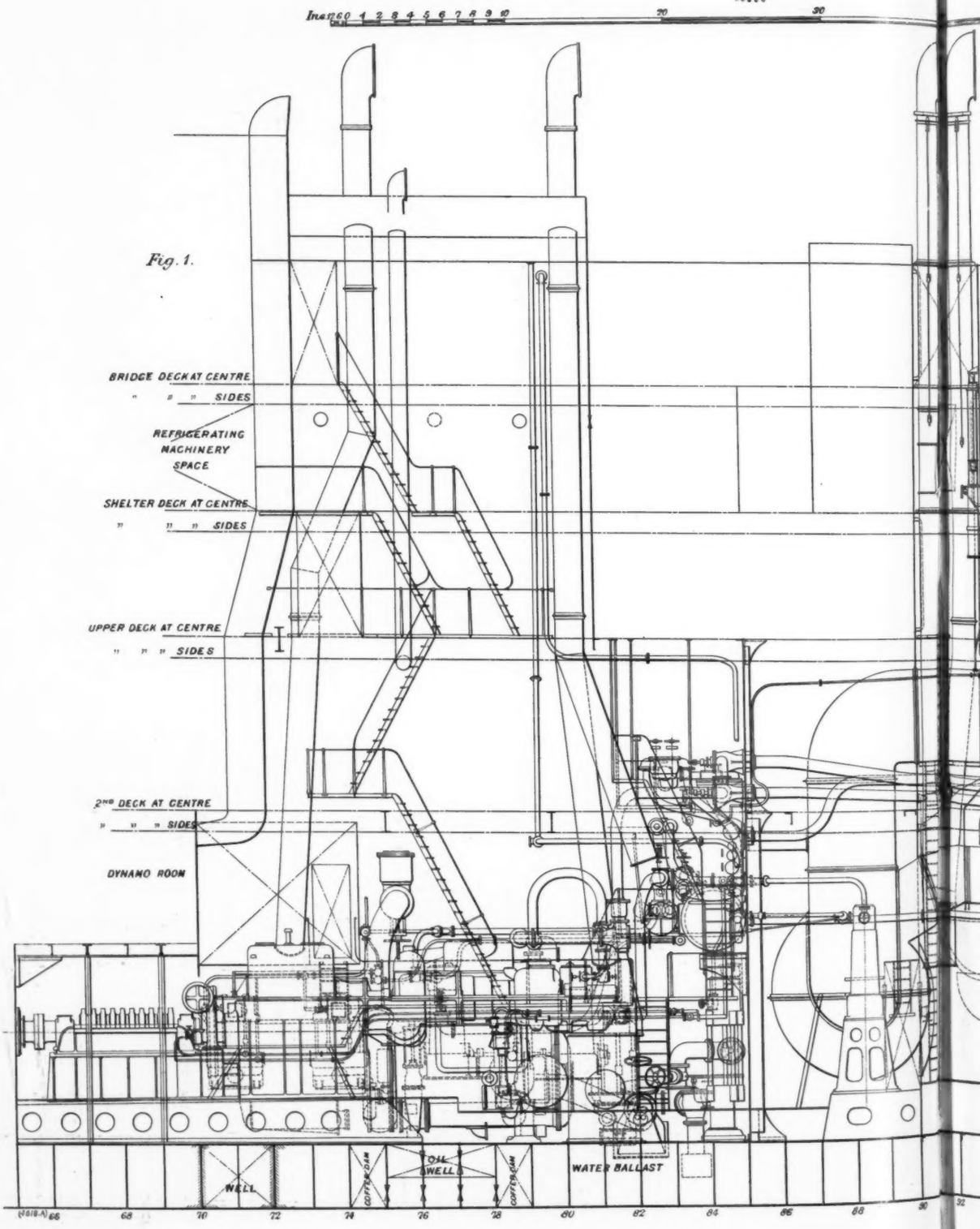
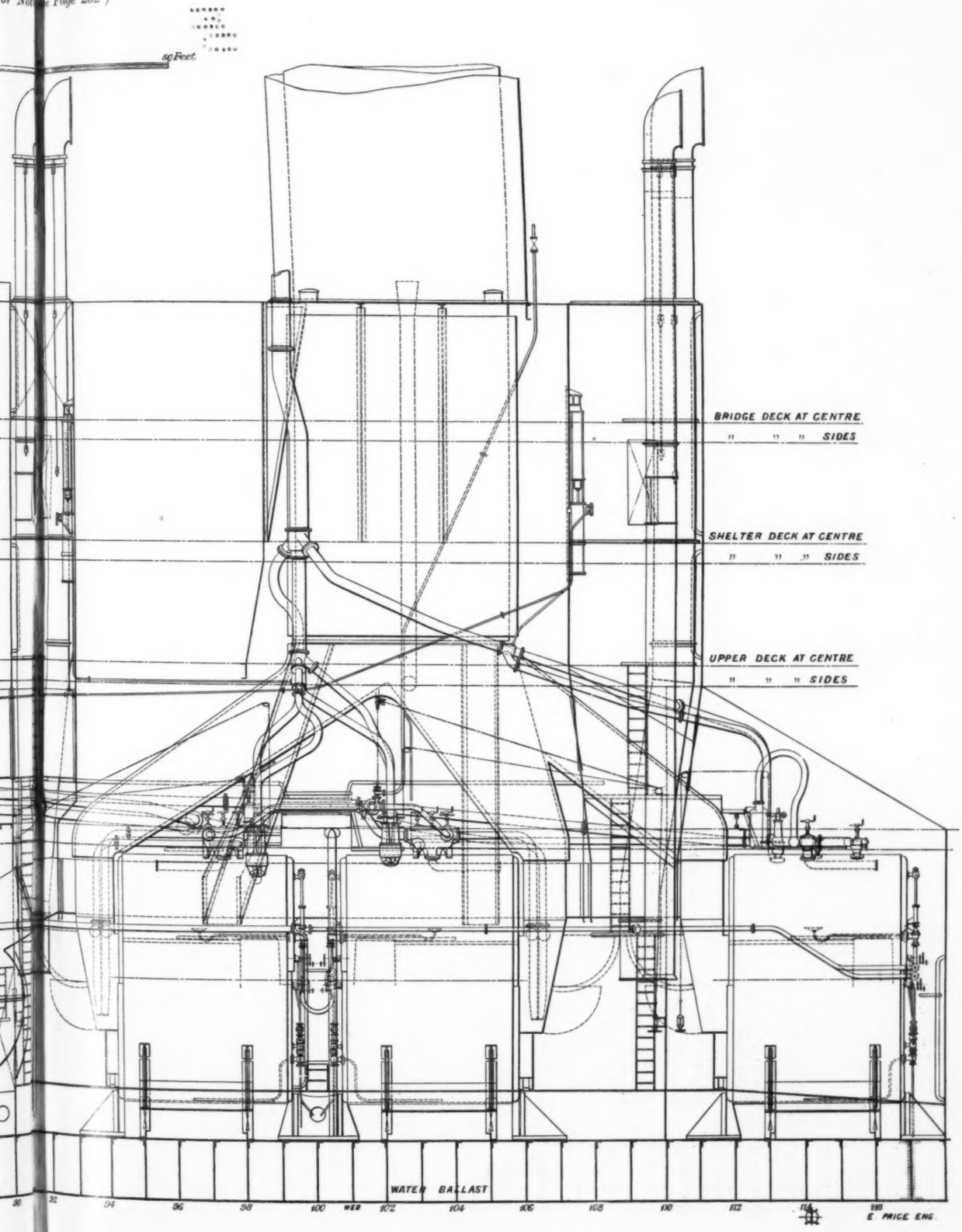


Fig. 1.

ELLING MACHINERY OF THE FEDERAL LINER "NORTHUMBERLAND."

Y AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(For Notice Page 252)



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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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Thin paper copies	£1	11	6	(£7.65)
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Thin paper copies	£1	16	6	
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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8596 GERRARD.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 17, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Paper on "The Composition of the Exhaust from Liquid-Fuel Engines," by Sec. Lieut. Robert W. Fenning, R.E. (T.), B.Sc., D.I.C., of London.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 21, at 5.30 p.m. Paper to be submitted for discussion:—"The Rangoon River-Training Works," by Sir George Cunningham Buchanan, C.I.E., M. Inst. C.E.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, March 21, at 8 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, W.C. After the Valedictory Address by the President, the following paper will be read:—"The Natural-Gas Industry, its Progress and Importance," by Dr. J. A. Leo Henderson, F.G.S., M. Inst. M.M. The chair will be taken by the President, Sir Boverton Redwood, Bart., D.Sc., F.R.S.E.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, March 21, at 5 p.m., at the House of the Royal Society of Arts. There will be a discussion on "Some Aspects of the Design and Use of Glassware in Relation to Natural and Artificial Illumination."

THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.—Tuesday, March 21, at 4.30 p.m., at the Queen's Hotel, Leeds. A paper on "Pit Timber and its Preservation," by Professor Percy Groom, M.A., D.Sc., F.L.S., of the Imperial College of Science and Technology, will be read. "Notes on the Uses and Markets for Coke-Oven By-Products," read at the January meeting, will be open for discussion.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, March 22, at 8 p.m., at the Royal Institution, Colquitt-street, when a paper will be read by Mr. G. S. Baker, M. Inst. N.A., entitled "The Immediate Commercial Advantages of Experiment Tank Tests."

THE ROYAL SOCIETY OF ARTS.—Wednesday afternoon, March 22. A paper on "The England of Shakespeare" will be read by the Rev. Peter Hampson Ditchfield, M.A., F.S.A. Mr. Hubert Hall, F.S.A. (Public Record Office), will preside. The chair will be taken at 4.30 p.m.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, March 23, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, W. Annual general meeting. Presidential address by Sir Richard A. S. Redmayne, K.C.B.

THE PHYSICAL SOCIETY OF LONDON.—Friday, March 24, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: 1. "A New Method of Determining Ionic Velocities," by Mrs. Griffiths. 2. "An Explanation of the Migration of Ions," by Mr. S. W. J. Smith, M.A., D.Sc., F.R.S. 3. "A Method of Exhibiting the Velocities of Iodine Ions in Solution," by Mr. S. W. J. Smith, M.A., D.Sc., F.R.S.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 24, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-on-Tyne. The discussion on "The Education of Youths before and during their Apprenticeship," by Principal V. A. Mundella, Member.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 24, at 5.30 p.m. A discourse will be delivered by Professor W. M. Bayliss, M.A., D.Sc., F.R.S. The subject is "The Mechanism of Chemical Change in Living Organisms." Afternoon lectures next week at 3 o'clock.—Tuesday, March 21. Professor Arthur Keith, M.D., LL.D., F.R.S., Conservator of Museum and Hunterian Professor, Royal College of Surgeons of England, on "Sea Power as a Factor in the Evolution of Modern Races" (Lecture II.). Thursday, March 23. Professor H. E. Armstrong, Ph.D., LL.D., F.R.S., on "Organic Chemistry in War—Organic Products used as Propulsive and Explosive Agents" (Lecture II.). Saturday, March 25. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres. R.S., Professor of Natural Philosophy, Royal Institution, on "Radiations from Atoms and Electrons" (Lecture III.).

S.S. "PERSIA" AND S.S. "MALOJA."

The Publisher desires to notify subscribers to "ENGINEERING" in the East who did not receive their copies of "ENGINEERING" of the issues of December 17, 1915, and February 25, 1916, that they may have gone down with the mails in the S.S. "Persia" and S.S. "Maloja." A few copies are still in stock of each of these issues, and may be secured at the ordinary rates, plus postage.

ENGINEERING.

FRIDAY, MARCH 17, 1916.

THE LOAD-LINE COMMITTEE REPORT.

THE assignment of freeboard to merchant ships is probably the most complicated shipping problem which has been subjected to legislative enactment, and there is certainly none which is more intimately related to the commercial aspect of the design and trading of ships. The Report of the Load-Line Committee just published is therefore a document of the highest technical and practical importance, because the visible results of their labours, as formulated in their revised freeboard regulations, will undoubtedly express the British views at an international conference, when one becomes possible. It is thus necessary to consider the Committee's report with the knowledge that these rules, or something like them, may ultimately govern the loading of the whole world's shipping.

The membership of the Committee was such as to ensure the fullest confidence in their recommendations, not only on the part of shipowners in this country, but practically throughout the world. The chairman was Sir Philip Watts, K.C.B., F.R.S., who has shown by his work a wide grasp of all problems affecting the loading of ships. The other members included Sir Archibald Denny, Bart., LL.D., who was also chairman of the Bulkhead Committee, and has devoted a very large part of an active professional life to the solving of practical problems of design in connection with merchant ships. This can also be said of the representatives of the great registration societies—Mr. W. S. Abell and Mr. G. R. Mares, of Lloyd's Register, Mr. J. Foster King, of the British Corporation, and Mr. John Gravell, of the Bureau Veritas. Mr. Foster King was also a colleague of Sir Archibald on the other Committee, and, with the other representatives of the registration societies, has done on sub-committees a remarkable amount of research and experimental work in connection with the load-line. The Board of Trade was represented by Mr. W. David Archer, who is the Naval Architect of the Department. Sir William E. Smith, C.B., brought to the assistance of the Committee an intimate knowledge of technical problems. Another member who greatly assisted the deliberations, because of his maritime experience, was Captain A. H. F. Young. The Secretary was Mr. C. J. O. Sanders, of the Board of Trade, and the acknowledgment of the value of the assistance rendered by him to the Committee was thoroughly well-merited.

The terms of reference to the Committee are simple in their wording, but sweep into the net of examination a tremendous quantity of material, and it is evident from the report that the Committee have taken a most comprehensive view of their duties. The President not only asked the Committee to advise the Board of Trade as to the attitude which should be adopted by the British representatives at the forthcoming International Conference on the Load-Line, and for that purpose to inquire and report whether, and, if so, in what respects, the tables of freeboard revised by the Board of Trade in 1906 need further revision in the light of the experience gained since that date of their practical working and effect, but invited advice upon the subject of a special load-line for timber-laden vessels and the regulations for the carriage of deck cargoes of timber which they consider might properly be adopted internationally.

The Committee have gone about their work in a thoroughly practical fashion, and have taken very little for granted. Although they possessed, through their own members, the comprehensive knowledge of freeboard work which belongs to the Board of Trade and the three classification societies who have been administering the British Load-Line Acts since they came into operation in 1890, they have examined three score witnesses who were representative of shipowners, master mariners, officers and seamen, and they have analysed all the information which shipbuilders and shipowners have placed freely at their disposal, as well as masses of statistics. They have also visited more than a hundred vessels, in order to see for themselves the character of the protection which is afforded to ship and crew by different kinds of superstructure, the nature and condition of the means for securing the hull against the possible ingress of water from the weather-deck through hatchways, ventilators, casings, &c., and the actual conditions which attend the loading of ships with timber and other cargoes.

One of many indications of thoroughness is shown in the beginning of the report by a most interesting *résumé* of the history of freeboard regulations from the time when public agitation procured the legislative enactment of the "Plimsoll mark." It will probably be news to many people that the original "Plimsoll"—a name which made so deep an impression upon the public memory that all load-line marks are still familiarly known thereby—had no technical meaning or value. The owner was free to place the mark at whatever height he pleased, but the law would not allow it to be submerged. This may sound absurd to-day, but in 1875, and for many years after, it was a real safeguard. The necessity was placed upon the owner of advertising on the ship's side the maximum draught to which he was prepared to load his ship, and in those days of sailing ships and of general similarity of design, the practical mariner got a very good idea whether he would like to sail in her or not. It is obvious that voluntaryism as to position of the load-line mark could not long exist beside legal authority to stop ships from overloading, because the resulting contests, which still remain in the minds of many of us, were bound to induce some sort of legislative definition of what constituted overloading. There can be no doubt that such a definition was a vital necessity in the case of sailing ships, and there must always have been plenty of data upon which to construct a standard for a safe and reasonable height of side for existing ships. Yet there was no

legal enactment on the point till 1890, when the glory of the sailing ship had already departed.

It may not be desirable at this time of day to discuss whether compulsory freeboard minima for sailing ships should have been coupled with similar laws for steamships, because during a whole generation the British mercantile marine has been designed, built, and handled on the basis of statutory draughts. Difficulty in advising as to whether the tables of freeboard, as revised by the Board of Trade in 1906, need further revision must, however, have been greatly complicated by the practical impossibility of arriving at limiting factors which definitely govern the freeboard of modern steel steamships from the point of view of safety in relation to height of platform.

The request for advice was apparently prompted by what the report calls a widespread distrust by seafarers of the alteration which was made in 1906, by something in the nature of an agitation which had grown out of that distrust, and by certain decisions which had been given by courts of inquiry into the losses of ships. Broadly speaking, the 1906 alteration consisted in the granting of smaller freeboards to ships which have complete and long superstructures of the modern type, and the course adopted by the British Load-Line Authorities seems to have been based upon such sound considerations that the 1906 tables have been adopted by practically all the maritime countries in Europe.

In view of that agitation, restricted as it was, and the distinct allegations made in some instances that British ships were being overladen, with resulting loss of life and property, the Committee have made an exhaustive examination of the available facts as furnished by evidence and by a huge mass of data with regard to the losses of lives and vessels, compiled from the official records for the seven years before and after 1906. These statistics appear to have been examined from every possible point of view, and there seems to be no escape from the Committee's conclusion that the revision of the Tables of Freeboard of 1906 cannot be regarded as having caused an increase in the loss of life or property at sea. In fact, if freeboard was really the dominant factor in these disasters, the figures would prove the precise opposite. The Report suggests that the statistics provide ground for the belief that freeboard occupies a minor place in the factors which affect safety at sea, in comparison with the character of the protection afforded by superstructures, casings, hatchways, ventilators, &c., and the dangers of improper loading.

The Committee deals specifically with the cases of the North Briton and Walter Gervase, in connection with which the courts of inquiry have expressed the opinion that the freeboards of these vessels were insufficient. With what seems to be characteristic, if rather unusual, downrightness, the Committee state that freeboard had nothing to do with the loss of either of these ships. The examination of shipowners and of "men who go down to the sea in ships" also seems to have supported the Committee in their conclusion that the 1906 freeboards are satisfactory in the main, as applied to the vast bulk of sea-going ships, and quite sufficient to ensure the safety of vessels—a conclusion which is in accord with the purely technical aspect of freeboard in relation to the actual safety at sea of steel steamships having properly protected openings. The Committee, however, are of opinion that modifications in freeboard details might be made in order apparently to avoid anomalies which are politely described as preferential treatment.

This brings us to the revised edition of the Freeboard Rules which the Committee have drawn up. We do not propose to examine them in detail, but we must refer to the admirable simplicity and directness with which they have been expressed. The present rules have been built upon the foundation designed in 1885 and laic in 1890, while the superstructure has been altered, extended, and amended to meet the exigencies which have arisen during a whole generation of practical use. It is not wonderful, therefore, if they are complicated in form and produce little anomalies in practice; but it has to be admitted that the present load-line regulations show this difference from most other similar enactments, that comparatively frequent alterations have been made from time to time, and, on the evidence of the present report, these alterations have been fairly successful in keeping the rules in line with modern progress. Nevertheless, the Committee are right in believing, and are to be admired for recommending, that a clean sweep should be made of the old externals, and in submitting for international consideration a code of rules which are so direct and simple that any one can understand and apply them.

The Committee take the Board of Trade entirely into their confidence and express the alterations they propose in a series of diagrams which show their effect upon the freeboards of practically every possible kind of ship. At the same time they illustrate with striking candour the relative incoherence of the existing rules. Generally speaking, the most important difference between the present rules and the new proposals is the value which the latter attach to sheer in every class of ship. Under the new rules it is proposed that the standard of sheer for flush-deck ships shall be much increased, and that existing freeboard minima will only be granted in cases where the sheer of the weather-deck corresponds to a standard which agrees with the best practice of the present day. The point of this change lies in the fact that under the present system a certain freeboard is granted to ships having complete superstructures, which is supposed to be so much greater than would be given to a flush-deck steamer of the same depth to the weather-deck, that the presence or absence of sheer becomes a matter of no importance. The diagrams A 1 to A 3 in the report, however, which illustrate the position of the flush-deck freeboards of both types, expressed in terms of length of ship, demonstrate that in many cases there is at present no such excessive margin of freeboard. Indeed, if it be the case that the dotted curves C give the freeboards appropriate to flush-deck steamers with sheer, in comparison with the dotted curves B for complete superstructure ships having no sheer, then there would in many cases be practically no margin between the two types if neither have sheer.

The opinion is expressed by the Committee that the existing rules for small flush-deck vessels are not altogether suitable, and from their proposals they evidently think that all flush-deck vessels, whether they be of the type usually known by that description, or whether they be of the complete superstructure or awning-deck type, require all the protection against being swept by head seas that sheer can give them. There are, of course, very few pure flush-deckers, except fishing vessels, and they have always a very large sheer forward, due to trim and actual sheer, which proves that the Committee's views in this respect are supported by practical experience. As a matter of fact, the present freeboard rules have favoured the tendency of practice to increase sheer in most other classes of sea-going steamers, and we believe that the line taken by the Committee will be in accordance with practical opinion, apart altogether from its evident technical propriety. Although the penalty for its absence will be heavy, it would be difficult to contend that it is out of proportion to the protective value of sheer in a seaway, or in the event of accident to an end compartment.

A marked change is proposed by the Committee in the method of assessing the freeboard value of detached superstructures, which has the merit of being clear, logical, and consistent—no one of which adjectives justly apply to the existing system—as expressed in the regulations and the sixteen diagrams prepared by the Load-Line Committee. It is evident that the protective value of, say, a 40 per cent. forecastle is entirely unaffected by the length of the poop, or any other detached superstructure, yet the principal novelty of the new proposal lies in the introduction of a type factor which removes the present anomaly that any particular superstructure—say a forecastle—obtains a freeboard value which does not depend upon itself, but upon the total length of the superstructures of which it forms one. Complete superstructures, the detached superstructures of well-deck vessels and of three-island vessels, are taken at full value; but the factorial value of other types or combinations of superstructures is diminished in terms of their protective value, until it falls to 50 per cent. in the case of a short poop by itself. The percentage of the length of the superstructure, which is to be taken for allowance purposes, is obtained by multiplying the actual length which it covers by the appropriate factor; but this again is subject to modification in terms of the means of closing the ends of the superstructure. These are of two classes: Class I. is either an intact bulkhead, or one in which the openings are closed by steel covers practically water-tight and permanently attached to the bulkhead; Class II. is a bulkhead in which the openings are closed by hinged hard-wood doors or weather-boards fitted in riveted channels for the full height of the bulkhead; all other means of closing are regarded as non-existent. This would represent a drastic change from present practice, but its adoption should provide a most wholesome improvement in the effectiveness of the protection afforded by superstructures, as it would only grant full value to superstructures which fully protect that which is enclosed by them. Briefly put, the proposed rules appear to leave freeboards very much as they are in the great bulk of ships (where superstructures are satisfactorily enclosed and a good sheer is provided); there will be consistency as between ship and ship and between superstructure and superstructure; but inferior arrangements will be more severely penalised than at present.

The original load-line tables of the 1885 Load-Line Committee were constructed upon the idea that a certain percentage of reserve buoyancy should be available in every ship in order to provide what seamen call "lifting power." Open superstructures seem to have been regarded as providing reserve buoyancy or effective displacement when pitching or rolling, and perhaps they did, so long as the water did not come inside them. Reserve buoyancy fails to establish itself as a sound "safe-freeboard" principle when its use provides different percentages of reserve buoyancy for different sea-going steamers, for the obvious reason that 1 per cent. of reserve buoyancy provides unsinkability for any intact hull, and the same percentages will produce the same margins of lifting power in all ships of similar form. However, "reserve buoyancy" were potent words in those days, and they prevailed; but in the years which have passed they have diminished in value and in frequency of appearance among freeboard regulations, until in this present year of grace they seem to have fallen so low in the esteem of freeboard authorities that they are not even mentioned now by the Watts Committee.

Height of platform is a necessary consideration in steamers of ordinary design, and the Committee have provided for this; but it is more than probable that in the modern steamship the chief factor in providing safety for life and property at sea is not freeboard or height of platform as much as the provision of invulnerable protection to the openings in the weather-decks against the attacks of the sea. It is to be feared that absolute invulnerability to the forces of Nature can never be achieved; but no effort should be spared that will help to approximate to that end. That the Committee are strongly of that opinion is shown throughout their Report and by the recommendations contained in Section IV. of their proposed regulations, where they lay down, as conditions of assignment of freeboard, certain standards of efficiency for the means of closing and protecting openings in weather-decks and in the vessel's sides. This section is a thoroughly practical attempt to meet the needs of the case: the construction and arrangement of machinery casings, cargo and other hatchways, companion-ways, ventilators, deck openings within superstructures which are not fully enclosed, side-scuttles, scuppers, valves, freeing-ports, rails and gangways have all been the subject of minute consideration and just appreciation of the vital elements they form in the problem of safety at sea.

The proposal of the Committee that the requirements expressed in this section should receive immediate acceptance by the Board of Trade is one which must be welcome to all who know anything of sea-going conditions. The value of the collaboration of the classification societies with the Board of Trade in the assignment of load-lines has nowhere been more clearly evinced than in the immediate action which has been taken by the British Corporation, Lloyd's Register and the Bureau Veritas in giving effect to these requirements in their rules, but their application should be universal and compulsory. It is evident that precautions of this kind might soon cease to be of practical value unless the good condition of the protection to openings is maintained by means of constant supervision, and it is to be hoped that speedy effect will be given to the further recommendation of the Load-Line Committee that freeboard certificates should be endorsed annually with the evidence of

a surveyor that the efficiency of this protection is fully maintained.

In view of the fact that the assessment of freeboard for many classes of ship is governed rather by considerations of strength than height of platform, it is obvious that some standard of strength of structure is required. This difficult and thorny problem appears to have been solved in the past by the collaboration of the classification societies with the Board of Trade, but for international purposes such a solution is scarcely feasible, and the Load-Line Committee therefore submit for discussion certain standards of least longitudinal and transverse strength which are certainly simple in form. They state that the basis upon which they have erected these standards has been derived from an average of the minimum requirements of the British Corporation, Bureau Veritas, Germanischer Lloyd and Lloyd's Register. There can be no dispute that the area of practice covered by such a basis is fairly comprehensive, representing as it does a very large proportion of the merchant shipping of the world. It has to be remembered, however, that classification rules only deal with average ships, and that no practice of this kind is immutable; in fact, very great changes in the standards of some of these societies have been made within quite recent years. The Committee have been careful to limit their proposed standards to ordinary sea-going cargo-steamers; but these limits comprise the great bulk of existing tonnage, and it is to be hoped that nothing may be done or suggested which is likely to stereotype, to hinder the development of superior structures in the future, or to induce inferior standards of construction through the introduction of Government minima for main scantlings. By admitting that passenger vessels and exceptional types require exceptional treatment, it appears to us that the Committee also admit that their strength standards are not to be accepted in too hard and fast a spirit; and it is to be hoped that if and when these standards become international this attitude will also become international.

If they are to be judged by their report and by the character of the alterations proposed in their new rules, the Load-Line Committee are satisfied that, so far as is ascertainable from experience, freeboard should be measured by the least height of platform which affords, under moderate conditions of sea, a reasonably comfortable ship to handle, and that safety is a question of so thoroughly protecting all weather-deck openings, and providing such ample means of freeing the weather-decks from water, that the risk of foundering under extreme conditions of weather is reduced so far as is humanly possible. We agree with this attitude, and we feel that freeboard for steamships is not a problem which is readily soluble from purely scientific considerations, but we also feel that the report of Sir Philip Watts's Committee is the best attempt which has yet been made, and possibly the best attempt which can be made, to combine the many conflicting attributes of the question. The directness with which opinions are expressed, the clear way in which the scientific and practical aspects of freeboard are stated in letterpress and diagrams, and the evidence which it bears of painstaking care in analysing all sides of the question, justify the conclusion that the report of the Load-Line Committee of 1915 is commensurate with the standing of its members and the importance of the subject.

RADIATIONS FROM ATOMS AND ELECTRONS

FOR some years past, Sir J. J. Thomson, P.R.S., O.M., has given a course of lectures at the Royal Institution in which modern views on physical science are set forth in plain language and with singular lucidity. The subject chosen for this year's course is that of the "Radiations from Atoms and Electrons," and the first lecture was delivered on Saturday afternoon last.

In opening his address, Sir J. J. Thomson said that the main object of studying the radiations from atoms and electrons was to form some idea as to the character of the mechanism at work within the atom by which the observed radiations were produced. In this first lecture he proposed, he said, to consider certain difficulties met with in interpreting, by this study of the radiations, the nature of the vibrator in which they had their source. He would illustrate these difficulties by the case of light. Discussions as to the real nature of white light had been very prominent during the past twenty years. Until Lord Rayleigh called attention to the subject it had, in fact, been thought that the existence of interference bands necessarily implied a very great regularity in the vibrations of the luminous body producing the light. He would, however, he thought, be able to make clear that these interference effects did not provide an unambiguous method of getting at the nature of the vibrators concerned. It was now held, in short, that the regularity of ordinary interference bands had nothing whatever to do with the vibrator, but depended entirely on certain peculiarities of the instruments used, or of the medium passed through by the light in the interval elapsing between its emission and its reception on the screen. He would, he proceeded, illustrate this by experiment. Having a long piece of stout rubber tubing stretched between the lecture-table and the ceiling of the auditorium, Professor Thomson showed that on striking the lower end of this tube a sharp blow, the resulting disturbance travelled up the tube to its point of suspension, and was then reflected back again, the "hump" produced by the blow running up and down the tube two or three times. He called attention to the fact that during the whole of this time the "hump" retained its shape unaltered. There was no tendency for it to spread over a greater length of the tube, but during the whole period of its existence the disturbance at any moment was confined to a short length only. The phenomenon, in fact, corresponded closely to that produced by a sharp tap or by the crack of a whip, the noise of which was propagated through the air, and at each point reached, the sound lasted only as long as the time originally taken to produce it. The sound, in fact, remained sharp, without any tendency to prolongation. Under certain conditions, however, it was possible, he said, to prolong the sound of such a crack and to make it equivalent to a musical note lasting a much longer time than the original disturbance, although the latter had itself none of the characteristics of a musical note.

Possibly some of his hearers had observed that if they stood at a little distance in front of a long flight of steps, the sound made by clapping the hands was reflected back by the steps as a prolonged echo, equivalent to a musical note of definite pitch. This effect arose because the foot of the disturbance on meeting the nearest step was reflected back, but the rest of the impulse passed on until it met the riser of the second step, from which another portion was reflected, and so on for the rest of the steps. The case was, in short, equivalent to that of thunder and lightning. The sharp crack due to the flash lasted only an infinitesimal time, whilst the thunder was due to a succession of reflections of this sharp crack from different clouds. In the case of the steps, as the distance passed over by the disturbance between each successive reflection was the same, there was a definite and identical interval between the successive reflections reaching the ear, and the sound received had accordingly the character of a musical note, although it originated in a disturbance possessing nothing of this character. The extent to which this note was prolonged depended, moreover, solely on the number of the steps, and not at all on the time during which the original disturbance lasted. In fact, from the report of a pistol a sound could be obtained lasting as long as there were additional steps to act as reflectors.

It would thus be seen that the study of a noise as received by the ear need not necessarily be a guide to the character of the disturbance which originally excited it, but might give merely the number of steps in the reflecting object.

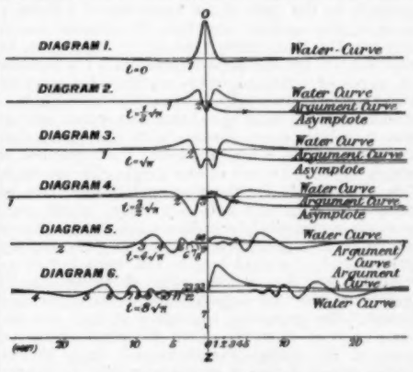
As a further illustration of the principle here involved, the speaker took another tube of rubber similar to that already mentioned, but to which at equally-spaced points of its length a series of weights had been secured. On repeating his original experiment the sharp hump produced initially was partially reflected as it passed each of these weights, with the result that a disturbance having a periodic character was reflected down the tube.

The application of these analogies to light would, he said, be apparent if a grating were considered as consisting of a number of equally-spaced reflecting bands separated from each other by transparent intervals. Light reaching the grating from any source would be reflected in a regular succession of separate disturbances, and the final result would depend entirely on the grating, and not at all on the character of the original disturbance. If the reflecting bands were sufficiently numerous, interference effects could be obtained, but these would be merely a measure of the fineness of the grating and could tell nothing as to the periodic nature or otherwise of the original disturbance. Hence, even when the velocity of propagation was the same for all disturbances, we could produce a regular succession of waves, even when the original disturbance was a sharp pulse. An explanation could thus be obtained of the action of a grating in giving a regular spectrum even if the original source were as disconnected and as abrupt as possible. It was accordingly impossible to tell from the reflections produced by a grating anything as to the nature of the source, since the grating would produce light of definite wave-lengths, even when there was nothing of the kind in the original light.

The discussion of the corresponding effect produced by prisms was more difficult. Suppose, for example, an irregular disturbance to enter a refractory medium. Such media did not transmit all disturbances at the same speed; and the consequences were important.

To illustrate this the speaker took as a model of such a medium a Kelvin "wriggler" suspended from the ceiling of the lecture-room. This "wriggler" consists of a long vertical wire crossed by heavy horizontal bars of wood fixed to the wire at regular intervals. Using this piece of apparatus, the lecturer showed that if the lowermost of the cross-bars were given a disturbance, a sort of wave ran up the wriggler, but with the added peculiarity that the farther the disturbance travelled the greater was the number of cross-bars affected. The disturbance, which was represented at the bottom by a sharp jerk affecting one bar only, had thus spread over a dozen or more before it reached the top.

A still better illustration, the lecturer proceeded, of the principle involved was afforded by waves on the surface of water. If a stone were flung into a pond, rings spread out from the centre, which became more and more numerous as the distance from the origin increased, so that, quite far out, beautiful wave patterns could be seen over a large breadth of water. Lord Kelvin had, Sir Joseph proceeded, worked out the theory of such disturbances. Taking a disturbance represented by the heaping-up of the water into a single hump at one point, he had calculated the form of the water surface after the lapse of different intervals of time. The results are represented in the subjoined diagrams and show



that, as time went on, the disturbance took more and more the ordinary wave form, the original isolated hump being replaced by a series of waves. The wave-length of these waves was, moreover, greater the further the distance from the origin. In short, the original hump broke up into distinct series of waves, with the longest waves in front, and we thus got regular wave patterns produced by a simple splash. The general result was that any irregular disturbance communicated to a water surface was automatically sorted out into regular series of waves, the number of which depended upon the distance travelled. A prism, on receiving an irregular light pulse, behaved in an analogous way. The irregular pulse of light was spread out by the prism into an immense series of perfectly regular waves, the number of which depended on the distance

travelled in the prism and had little to do with any regularity in the vibrator in which the pulse originated. This action of a prism was, he went on, due to the fact that the velocity of light in a dispersing medium depended on the wave-length. The easiest way of considering the matter was to analyse the original disturbance into a series of waves by means of Fourier's theorem.

Fourier had proved that any kind of disturbance whatever, could be represented as a series of regular waves superimposed one on the other. This held even were the disturbance equivalent to an abrupt noise.

In fact, any noise whatever could be reproduced by striking, suitably and simultaneously, a series of tuning-forks of different pitches. Each of these forks emitted its own musical note, and by simultaneously striking the appropriate forks, any noise, no matter how abrupt and discontinuous, could be reproduced. Further, it was possible to have the forks all in motion for some time, with resultant silence, and for them then to give an abrupt noise and to subside into silence again, while still continuing in motion, the silence before and after the noise being due to the mutual interference of the effects due to each individual fork.

The initial "hump" on the water surface in Lord Kelvin's problem could accordingly be considered as made up by the superimposition of waves of different wave-lengths. A peculiarity of water and of glass and other dispersive media was that the speed of wave transmission depended on the wave-length. In the rubber tube used in the first experiment shown, the speed, on the other hand, was the same whatever the wave-length, and this was also true of sound-waves in air, so that a tune played by a band was heard as a tune whatever the distance of the auditor. The waves into which the hump could be resolved all travelled along the rubber tube at the same rate, and the disturbance accordingly retained its shape, as had been seen. In the case of water, however, the series of waves, into which the initial hump could be resolved, travelled with different velocities, those of longer wave-length travelling faster than their shorter fellows. Hence at the front of the disturbance resulting from the subsidence of the hump, long waves predominated, and the shorter waves were left behind. The further away from the centre the greater was the separation, and possibly, if one could get far enough away, the leading waves would be accurately "monochromatic."

To show how the waves corresponding to an abrupt disturbance of a water surface could be analysed the lecturer exhibited the following experiment:—A thin stream of water was allowed to run down an inclined sheet, and a reflection of its surface was thrown on to a screen. An obstacle in the path of the water caused a disturbance of the surface, and this disturbance could, the speaker said, always, whatever its nature, be represented by the superimposition of a number of waves of different wave-lengths. Amongst all these waves there would be one series travelling upstream with the same speed that the water surface was travelling down-stream, with the result that stationary waves were produced, the reflection of which was very evident on the screen. The waves in this case, Sir J. J. Thomson stated, were due to surface tension, and not to gravity, which was, however, responsible for ordinary sea-waves. Waves due to surface tension travelled the more rapidly the smaller the wave-length, and were known as "ripples," whilst in the case of waves due to gravity it was the largest waves which travelled fastest. By increasing the speed of flow, the lecturer showed that the pitch between successive crests of the ripples was shortened, since at the higher speed it was a component with a shorter wave-length that moved up-stream as fast as the water flowed down. By reducing the velocity of flow, a point was reached, the lecturer showed, at which all signs of wave action disappeared. This was, he remarked, due to the fact that there was a certain minimum speed for the propagation of waves over a water surface.

The experiment just described showed, the speaker said, that by the action of the transmitting medium in selecting waves moving at a certain speed, we got a regularity which was quite independent of the exciting source. The phenomenon exhibited corresponded very closely with the action of the glass of a prism on light. No matter how irregular the disturbance entering the glass might be, it would be sorted out by the glass into perfectly regular series of definite wave-lengths.

It would be evident, the speaker continued, that the action of a prism in producing a spectrum was thus more fundamental in character than was usually supposed, so that the prism actually "coloured the light." In fact, apart from an action of this kind, it was difficult to see how a very short disturbance could in any circumstances produce the sensation of colour. There was, in fact, no conceivable mechanism by which a disturbance lasting for only a fraction of a vibration could be distinguished as a colour by the eye. For this to be possible it would seem necessary that at least two or three complete vibrations should be received, just as in music it was necessary for the ear to receive two or three complete vibrations if it were to distinguish the note. He held this view, he said, in spite of some statements which had been made to the contrary.

Hence, if a thin pulse of light, not lasting as long as a single vibration in the luminous spectrum, were received, it would not give the sensation of colour. On passing through a prism, however, a short disturbance of this kind would be lengthened out, and by having the path long enough as many vibrations as desired could be obtained. The prism, therefore, did much more to the light than it was usually credited with, at least in the older text-books on optics. In these, the view expressed was that the colours existed as a mixture in the incident white light, and the action of the prism was simply to disentangle these. From a purely mathematical standpoint this view was tenable, as a pulse, however sharp, could be considered as the resultant of an enormous number of superimposed vibrations. Physically, however, the action of the prism was not merely to split up these colours, but to prolong the time during which a disturbance lasted. This effect depended on the length of the optical path, and the number of definite waves produced from a sharp pulse was proportional to the length of this optical path.

From this point of view it would be seen that a study of light passed through a prism could give no certain indication as to the nature of the vibrator in which it originated, any more than could the light from a grating be taken as a conclusive criterion of the regularity of the source.

There were, however, some cases of interference which stood on a different footing. Michelsen's interferometer, for example, comprised nothing corresponding to a grating, and though lenses might be embodied in it, the optical path in these was not nearly long enough to account for the results observed.

Using this instrument, Michelsen had obtained interference between waves of mercury light, the lengths of paths of which differed by more than half a million wave-lengths. The significance of this observation might, he proceeded, be made clear by considering a corresponding case of interference by sound. Take, for example, he said, the case of a sensitive flame backed by a glass reflector. Then, if a sound were emitted from a suitable source, the flame would respond to the disturbances reaching it. Of these the one came direct from the source, whilst another reached the flame after reflection at the glass plate, and this reflected disturbance had travelled a longer distance than the direct wave. By suitable precautions matters might be adjusted so that the action of the one wave cancelled that of the other, and the flame remained unaffected accordingly. The point to be noted was that the reflected wave, having travelled over the longer distance, must have started from the source some time before the direct wave which it annulled. The longer the difference between the two paths the greater must be the time which had elapsed between the emission of the two interfering disturbances. In Michelsen's experiment, interference was obtained between rays, although the source emitted the one ray 540,000 vibrations after it had sent out the first ray; nevertheless a counterbalance was still obtained. This observation was usually taken to imply that an atom of mercury could sustain vibrations with such persistency that after half a million of them it was in action as vigorously as ever, and was, moreover, radiating all this time without any change of phase. This appeared hardly probable to the speaker. He did not, in fact, find it easy to realise how the necessary conditions for the interference could be sustained if the whole of the radiation was produced by a single atom. Such atoms were, for example, continually coming into collision with other atoms, and the consequent shock would alter the phase of the radiation emitted. It appeared, however, on making the appropriate calculation, that disturbances thus arising were unimportant, as the interval between successive collisions was very large in comparison with the time occupied in emitting half a million vibrations. A radiating atom was, however, also subject to shocks of another kind, as each was surrounded by others also emitting light, and to this light the atom was very absorbent. If it did pick any up, however, it would be thrown out of step, and the regularity necessary for interference effects would be destroyed. We should have, accordingly, to suppose that each luminous particle of mercury, during the time it was luminous, received no light. Such a supposition would, however, be inconsistent with the number of luminous centres present.

What really happened appeared to be that the necessary precision of phase was produced by the action of the light itself. The light that interfered was, in short, not derived from a single luminous centre, but from a considerable number of such centres forced into phase by their mutual interaction. It would seem that the stream of green light, in passing the atoms of mercury, excited them to radiate in phase with itself by fixing the time at which a particular atom began to be luminous, firing it off, as it were, in phase with itself. This phase was accordingly forced upon the active atoms. As one ceased to radiate another began, and the phase at which it started was fixed by the stream of light in which it lay. Some view of this kind was, he thought, necessary to make intelligible interference between rays having a difference of over half a milllion wave-lengths in the paths traversed.

HIGH-TEMPERATURE LABORATORY FURNACES.

INFORMAL discussions on a general type of machinery or apparatus, as distinct from the reading of set papers on some particular apparatus of limited interest, may afford useful guidance to those desiring to make an addition to their plant and tell them what minor troubles to look for in working the instruments and how to avoid them. The general discussion may, on the other hand, meander and lose itself in reiterations and into excursions into irrelevant features. The Faraday Society steered fairly clear of these pitfalls when holding an informal discussion on "Methods and Appliances for the Attainment of High Temperatures in the Laboratory," in the building of the Institution of Electrical Engineers on Wednesday last. The subject was very ably opened by Dr. J. A. Harker, F.R.S., who gave the meeting the benefit of his wide experience at the National Physical Laboratory.

Dr. Harker stated that the subject was very large, and he would not refer to arc furnaces, which were hardly suitable for the laboratory. Many experimenters had probably, like himself, tried to make a tubular resistance furnace by drilling out a cored carbon; that attempt generally ended in disappointment, for the carbon was too hard and brittle. The resistance of the carbon depended upon the density it had acquired during compression, and the temperature to which it had been heated in manufacture; the resistance would be 2000 or 4000 times as high as that of copper. The best graphite from Niagara had about a fifth of that resistance; it could be turned on a lathe like a hard wood, whilst most samples of carbon could only be worked with a grinding-tool. In designing a furnace, one should bear in mind that the carbon resistance, whose temperature coefficient was very low, sank to about two-thirds of its value at incandescence, and that hence the voltage then dropped, and the current increased. It looked rather wasteful to cut a tube into a spiral, but it was very convenient for the experimenter. The contacts of a tube furnace wanted for a few runs only might be made by wrapping round the ends stout copper sheet attached by bolts to the cables. But where the air gained access at unprotected portions, a neck would burn into the tube, and it was necessary to lag and to encase the furnace, also for the reason that all carbon gave off gases (CO mainly) which became dangerous unless burned within the furnace. The mineral impurities of the carbon also volatilised during the first high-temperature runs, and formed a fog in the tube, which condensed to cobwebs of the oxides of silicon and other elements. Brickwork setting did not keep gas-tight; at Teddington they had made settings of ferro-concrete held together by stout wire netting, and painted them over with silicates.

The expansion of the tubes caused no trouble if

the clamping allowed them to glide; the spiral tubes behaved splendidly in that respect, their springiness taking up the expansion. Figs. 1 and 2 show various tubes; the latter figure also illustrates the tubes through which the cooling water circu-

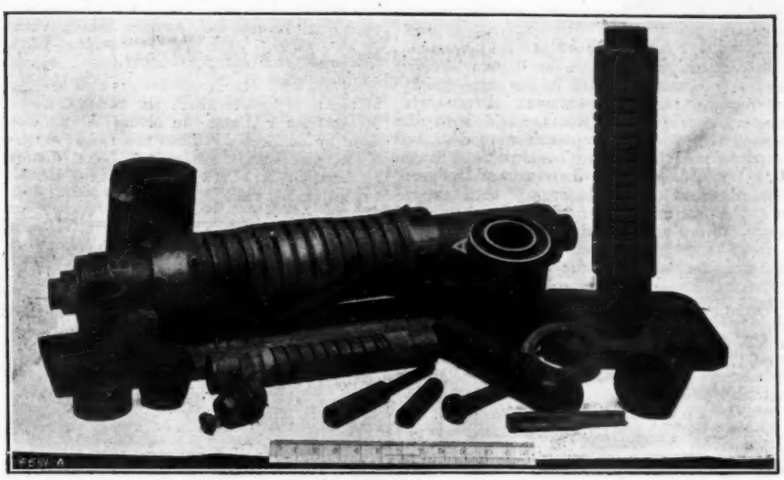


FIG. 1.

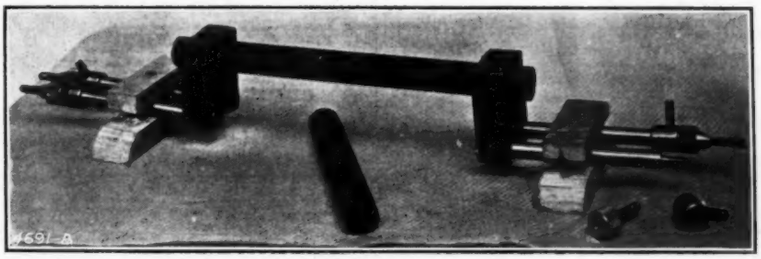


FIG. 2.

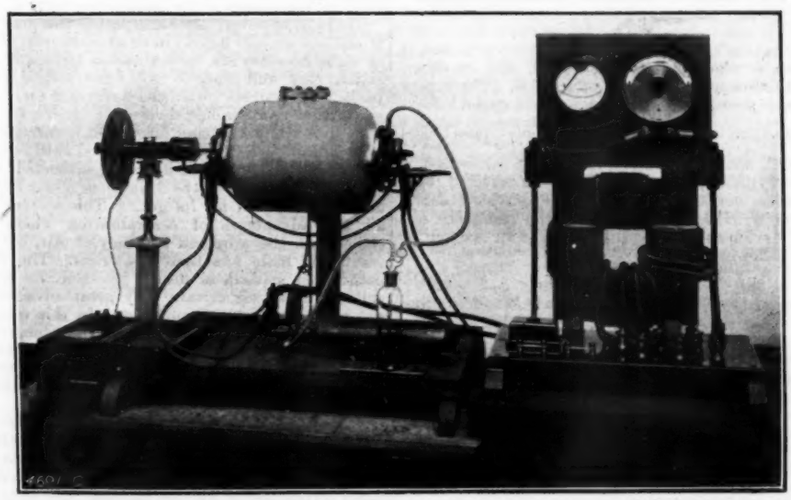


FIG. 3. CARBON RESISTANCE FURNACE; EDEN'S PATTERN.

lates. The cooling of the clamps was most essential, and in the furnace illustrated in Fig. 3 the discs closing the ends of the drum were likewise cooled. This furnace had been built mainly for the purpose of standardising optical pyrometers, and such a pyrometer is seen mounted in front of the furnace. The tube of the furnace which, Dr. Harker explained, was designed and made by Mr. C. G. Eden (formerly his assistant, now a consulting engineer), formed the longitudinal axis of the drum (aluminium casting) surrounding it; the whole inner space was packed with soot (presently to be referred to) which was introduced through the opening at the top. The clamps were attached to the end discs, which were bolted to the drum. The whole furnace was supported on a stand, on which it could be turned so as to be inclined at various angles. The clamps were lubricated inside with unctuous graphite; if they did not fit well, a better grip could be obtained also by the aid of several thicknesses of tinfoil. To insulate the space inside the drum simply by air was not advisable; carborundum and similar compounds would do, but they had found a soot produced by burning rag to answer best. This lamp-black was very loose and settled in the furnace; it gave off some hydrocarbons which might burn and give a cyanogen flame. The diameter of the graphite tube in that furnace would be about 1 in. When larger tubes, and especially when spiral tubes, were used, it would be advisable and possible to place tubular liners inside the tube, so as to protect the substance to be heated from the reducing furnace gases. Such liners could be made of zirconia; generally two liners, two concentric tubes, were mounted within the furnace-tube, and though the zirconia of the outer tube would partly be turned into carbide and become very hard, the inner tube would remain fairly intact. Alundum tubes were also applicable, and made very good refractory insulators; they were not gas-tight so far, however. To prevent the soot from falling through the spiral cuts, the tube was wrapped with a good filter-paper, almost free of ashes; the carbonised paper held the soot back afterwards. In this respect, Dr. Harker subsequently remarked, the soot was preferable to charcoal, which Dr. Greenwood had recommended during the discussion.

Passing to electric heating by means of loose granulated resisters — carborundum, cryptol (a material made of carborundum, graphite, and clay, granulated and dried somewhat like gun-powder), &c.—Dr. Harker said that such resisters proved tedious and unreliable at temperatures exceeding 1600 deg. or 1700 deg. Cent., because preferential paths of smaller resistances would frequently form in them, and the current would then chiefly heat these parts, so that unequal heating resulted. This was especially so with annular resisters; matters could sometimes be improved by splitting the ring which contained the resister. Another form of resistance furnace, convenient for some metallurgical studies, consisted of a fire-brick provided with two hollow cups joined by a zig-zag groove; the cups formed pools of molten metal. There was not much to be done with this type of heater, for the resistance of the molten metal was little or no higher than that of the solid metal. As regards economy, the furnace illustrated was generally fed from the simple transformer shown in Fig. 3, and required about 1 kilowatt to give a temperature of 2500 deg. or 3000 deg. Cent. The former temperature could safely be borne for a long time; during the demonstration a temperature of 2000 deg. Cent. was reached within three minutes. The cylinder shown by the side of the furnace in our reproduction of the furnace photograph is a vessel containing nitrogen or some other gas wanted for creating a special atmosphere.

At the end of the discussion Dr. Harker referred to vacuum electric furnaces. His experience with Arsem and other vacuum furnaces was not too encouraging; the radiation losses in them were great, and the pump had to be very efficient, because the evolution of gases from the carbon and the metallic parts of the furnaces went on for weeks and months, and unless a really high vacuum were maintained the deleterious effects of carbon were quite as bad as at ordinary pressures. Platinum-coil furnaces had to be handled carefully, because one could not at once send the full heating current through them; nichrome and carbon, still more, were not delicate in that respect.

We have already anticipated several remarks which Dr. Harker made in reply to questions put during the discussion. Dr. Desch wrote to ask for advice as to suitable furnaces for experimenting with silicates; Heraeus furnaces were not suitable, and the silit tubes of Siemens (Berlin) were troublesome at higher temperatures. Several speakers referred to optical pyrometers, for whose standardisation the Eden furnace was especially designed, as already stated. Sir Robert Hadfield, F.R.S., the President of the Faraday Society, had mentioned, in introducing Dr. Harker, that some 12,000 pyrometer readings were taken every week in his Sheffield works, and one of the two furnaces exhibited (the one illustrated in Fig. 3) was, in fact, destined for Sir Robert's steel works. These pyrometers (of the Wanner type) were provided with two scales, and had to be tested all over the range. Dr. Whipple, F.R.S., said that they were all glad that the National Physical Laboratory

and Dr. Harker had taken up the standardisation of optical pyrometers, after having supplied them with reliable radiation pyrometers. One war difficulty in connection with optical pyrometers had been the supply of red glass (obtained from Germany); Mr. Twyman had been able to help them with his store. Mr. Twyman afterwards remarked that gelatine screens could be used instead of the ruby glass, but Dr. Whipple did not quite trust these for the eye-piece. Dr. Whipple also referred to the gear-hardening furnaces of Messrs. Leeds and Northrup, which he had quite recently seen in works at Detroit, U.S.A.; wheels, 6 in. and 8 in. in diameter, were heated in these furnaces, the man watching until recalescence set in, and then quenching the specimens. That was another advance; the specimen itself indicated when the proper temperature had been reached, and standardised instruments were not required.

Dr. Rosenhain, F.R.S., said that in his search for optical-glass furnaces, where no carbon could be tolerated in the working space, he had tried a magnesia crucible wound with tungsten wire, and he had found with that furnace that pure iron melted at 1525 ± 5 deg. Cent. in a vacuum. But tungsten wire was very brittle at high temperatures, in hydrogen and nitrogen atmospheres, as well as in a vacuum. Dr. Harker confirmed this statement, but he also thought that something could be done with squirted tungsten tubes. As regards clamps, Dr. Rosenhain recommended to spray the contact surface of the carbon by the Schoop process with some metal (copper), and to burnish the metal; otherwise the current losses and local heating would be great at the clamps and also at electrode joints; that would betray itself by high voltmeter readings. With regard to gas furnaces, Dr. Rosenhain recommended two types: the Seger-Heinecke, in which the mixed gas and air passed up and down an iron pipe before burning; this was silent and useful for temperatures up to 1500 deg. Cent., but the atmosphere was reducing. For higher temperatures he used his blow-pipe; air at a pressure of 100 lb. per sq. in. entered a chamber which was provided with many apertures and ended in a neck to which the cast-iron nozzle was attached. This nozzle gave a flame 6 ft. long and more, which was very noisy; the flame would only light in the furnace, and the burner had to be withdrawn from the furnace before turning the air off, else the nozzle would melt.

That compressed-air flames were very powerful was further stated by Mr. Kent and Mr. Webb, from Messrs. Johnson and Matthey, who want temperatures of 3000 deg. Cent. daily in melting platinum, iridium, &c. For temperatures up to 1000 deg. they preferred nichrome furnaces. Mr. Kent had also tried zirconia, mixed with a little ceria as binder, and hoped, like Dr. Harker and Rosenhain, great things from zirconia. In the Brayshaw burner the high efficiency was partly due to the agitation of the gases, Mr. Kent remarked. Mr. Brayshaw himself explained this further; the gas-air mixture of correct proportions struck against a cone, and having passed through channels and blind pockets entered the burner through four holes. The gas in the blind pockets acted as a cushion producing whirls, so that the gas passed into the burner in the violently agitated condition favourable for the rapid propagation of explosive ignition. Mr. Brayshaw told the meeting how he had convinced the German Patent Office of the important part played by the blind pockets; they had objected that the pockets were as essential as the "appendix" was to the abdominal organs—i.e., essential for being removed by operation; the convincing tests had been made at the National Physical Laboratory. One objection to noisy gas-furnaces, which Mr. Darling pointed out, is that they are unsuitable for lecture-rooms and laboratories.

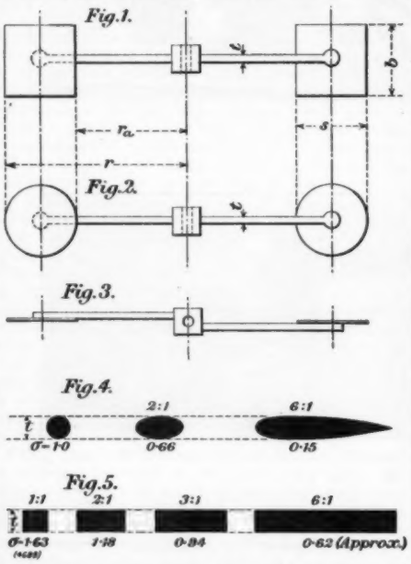
Dr. Greenwood, formerly in the National Physical Laboratory (now in the Army), where he did some excellent work on the boiling-points of metals, brought the discussion back to electric furnaces. For rough purposes he preferred simple brick settings, because the dimensions could then be easily modified, which was sometimes essential. A simple calibration of pyrometers, sufficient for certain purposes, could be obtained with the aid of narrow strips of pure platinum, rhodium or iridium, which were clamped and heated up in steps of 10 deg. or so until the rupture occurred.

As regards larger furnaces for casting ingots of 200 lb. of German silver and other alloys, electric furnaces were certainly preferable to gas and coke furnaces, and he had lately been experimenting with furnaces in which resisters were put in series, the current flowing from top to bottom.

In one of his concluding remarks Dr. Harker, who was assisted by Mr. Ezer Griffiths, drew attention to a good book on gas furnaces, written by Dr. Jaeger, of Groeningen.

THE FAN DYNAMOMETER.

FOR certain purposes the fan dynamometer is exceedingly convenient, but it has not hitherto been regarded as an instrument of precision. Some interesting experiments made with the object of removing this reproach were described in a paper read before the Institution of Automobile Engineers, by Mr. J. Lawrence Hodgson, on March 8 last. In the majority of these experiments, the fan used was revolved in water, but some tests were made in air, and a comparison of the two showed that both sets could be represented by the same formula, on assuming that in each case the resistance was proportional to the density of the fluid. Two forms of fan were used by Mr. Hodgson, of the shapes shown in Figs. 1, 2, and 3. The fan, it will be seen, consisted of a square or round paddle mounted at the end of a relatively thin arm. The section of this arm was, in some of the experiments, round, and in others of the shapes shown in Figs. 4 and 5. The experiments showed that the resistance depended, to some extent, upon the proportion of $\frac{r}{s}$ (see Figs. 1 and 2), but that once this ratio exceeded about 7 to 1 the resistance was practically unaffected by a further increase in the ratio. From his observations Mr. Hodgson states that the resistance of a fan dynamometer revolving in free air is given by the following formulæ:—



$$\mu_b = \kappa N^2 r^3 s^2 W. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\mu_a = 0.35 \times 10^{-8} \sigma N^2 r_a^4 t W \quad . \quad . \quad (2)$$

$$\mu = \mu_b + \mu_a \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$\text{H.P.} = \frac{\mu N}{63{,}000} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Where

W = density of the fluid in pounds per cubic foot.
= 62.33 for water at 50 deg. Fahr.
$= \frac{1.347 \times \text{barometric press. in inches of mercury.}}{(460 + \text{temp. Fahr.})}$

μ_a = torque due to arms in inch-pounds.
μ_b = torque due to blades in inch-pounds.
μ = total torque.
H.P. = horse-power.
N = revolutions per minute.
s = length of side of square, or diameter of disc in inches.
r = external radius of fan in inches.
r_a = radius of arm in inches, measured to inside of blade.
t = thickness of arm in inches.
κ = a coefficient which when $\frac{r}{s} > 7$ is about 2.04 for square blades and 1.58 for round blades.
σ = a coefficient depending on the section of the arms as given in Figs. 4 and 5.

When the ratio $\frac{r}{s}$ was less than 7 the resistance varied considerably with this ratio, being for square blades about 2.07 for $\frac{r}{s} = 6$; 2.27 for $\frac{r}{s} = 3$; and 2.15 for $\frac{r}{s} = 2$. The corresponding values for circular blades are 1.58 for $\frac{r}{s} = 6$; 1.68 for $\frac{r}{s} = 3$; and 1.63 for $\frac{r}{s} = 2$. In practical work Mr. Hodgson says that the diameter of the fly-wheel to which the fan is bolted should be less than r_a, and the blades should clear the floor by at least $1\frac{1}{2}$ times the radial width of the blade, and that there should be a distance of $1\frac{1}{2}$ fan diameters between the plane of the fan and any adjoining wall.

A MINISTRY FOR THE AIR.

THE Ministry of Munitions has undoubtedly proved remarkably successful, and there is now an active agitation to appoint a Minister having exclusive charge over all matters pertaining to aerial warfare in the hope and expectation of an equal degree of success. The problems concerned in the two cases are, however, by no means identical. In the one case the result was in the main merely a matter of organisation. The projectiles and other requisites were standard patterns, and it was merely a question of increasing the output. If it were true that existing patterns of aeroplanes would meet all the needs of the service, and that they were incapable of material improvement, the establishment of a Ministry to control the supply might have many advantages. We learn, indeed, that certain builders, whilst willing and anxious to work for the Navy, are reluctant to undertake corresponding work for the War Office. The reason given is the alleged absurdity of certain of the requirements embodied in the specifications prepared by the latter. Limits of precision are fixed for the woodwork which, it is stated, depend for their satisfaction on a continuance of favourable meteorological conditions. Obviously a degree of accuracy found satisfactory for naval requirements should suffice for the sister service. The establishment of a central controlling board would provide an opportunity for the revision of specifications and the omission of clauses put in apparently merely in order to facilitate inspection by officers devoid of technical skill or knowledge. Such a revision would, no doubt, make possible an increase in output, though we note that, according to the Under-Secretary of State for War, the deficiency has been rather in the number of engines than in the supply of the aeroplanes themselves.

There is, however, another aspect of the question. If matters are still largely in an experimental stage, as we believe they are, centralisation and standardisation may well prove to have some serious drawbacks. As matters stand, the Army and the Navy make use of independent corps of designers, and the danger of matters getting into a rut is correspondingly diminished. The Navy, indeed, will be slow to welcome a move in the direction advocated, as it cannot have forgotten the days when it was dependent on Woolwich for its guns. This system had all the advantages of centralisation which are claimed for the proposed Ministry of Air, but the result was little less than disastrous. The competition in matters of design between the Army and the Navy has certain very great advantages, and must tend towards progress. In this connection it is of interest to note that the exceptional excellence of the French guns dates from the time, still recent, when private firms in France were, for the first time, allowed to design and build ordnance for foreign account.

In France as in Britain independent centres of thought were thus established, which, in competition with each other and the rest of the world, made one improvement after another, each of which was duly taken advantage of by the national authorities as the occasion offered. The great importance of the advances made by the French armament firms is well illustrated by the fact that in all the international competitions held during the years immediately preceding the war Krupps were invariably defeated by their French competitors. No similar rate of progress would have been possible with all questions of design relegated to a single central board. The latter is certain, sooner or later, to get into a groove, a risk which is wholly obviated when there are independent

and competing "thinking centres." Organisation can, no doubt, accomplish much, but the larger the organisation the more difficult it is to move along a new path. This experience is universal. Not merely, moreover, are large organisations difficult to move, but if the control falls into the hands of the somewhat numerous class who believe that organisation can replace creative thought, the difficulties are intensified. The history of our military air service is a conspicuous example of this. Lord Haldane is, and was, a great believer in the effectiveness of mere organisation, and in this matter was no doubt responsible for the system which gave us, not merely our incomparable corps of "contemptibles," but also for the territorial system, which proved not only an exceptionally valuable second line, but provided the framework on which much of our enormous increase of numbers has been built up. On the other hand, from his treatment of the Wright brothers, it would appear that he had less sympathy with bold adventures into novel and untried paths. Correspondence recently published shows that he refused, not merely to consider the purchase of the Wrights' secrets, but also, in the curtest, and all but discourteous, manner, he declined to authorise anyone to attend a demonstration of the Wright machine. The Wrights accordingly arranged for the public exhibition in Paris, which awoke such surprise and admiration amongst the French aviators, who at that time had themselves travelled far on the road to practical success.

An Air Ministry under the control of anyone with a similar faith in the all-sufficiency of mere organisation would be disastrous, and as matters stand, even a very open-minded and enterprising chief would find it difficult to resist the temptation to stereotype designs, for the purpose of more easy manufacture, the almost unavoidable result of which would be long delays in the adoption of important improvements. As matters stand, the present arrangement of an Inter-Departmental Committee on the Air Service seems to have considerable advantages over the greater centralisation which would result from the establishment of the Ministry advocated in some quarters. This Committee will no doubt be greatly strengthened by the appointment, just announced, of Lord Montagu.

NOTES.

Ether Drift with Moving Matter.

When it is assumed, in accordance with the undulatory theory of light, that the ether pervades all space and all matter, the question arises whether that ether would drift with any matter or medium in motion, or whether the ether would remain stationary and allow moving matter to pass through it. Of the many experiments devised to test this question, only one has given a positive result—the original experiment of Fizeau, of 1859, and its later repetitions. Fizeau passed two parallel beams of light through tubes, through which water was running in opposite directions, and arranged the experiments so that the beam of light travelled in both the tubes against the water current; thus any effect of the motion of the water on the light-ray would be doubled. He actually observed a displacement of the interference bands by 0.46 width of a fringe, while he calculated a displacement of 0.404. The agreement was therefore satisfactory. Fizeau's formula was that the velocity of light in moving water should be $C = \frac{c}{\mu} \pm w$, where c was the velocity of light *in vacuo*, w the velocity, and μ the refractive index of water. Fizeau showed also, however, that not the whole w entered into the formula, but only a fraction of it, $\epsilon = 1 - \frac{1}{\mu^2}$, which is known as the Fresnel coefficient. In the case of water ϵ has the value 7/16, and the effect to be observed is, of course, exceedingly small, one part in 50 millions, as the maximum velocity of the water in the tubes (1.5 metre in length) was only 7 metres per second. Repeating the experiment with perfected apparatus, Michelsen and Morley in 1886 found, with tubes 6 metres in length, a displacement of 0.437; they split a ray of light by letting it fall on a slightly-silvered mirror, which transmitted part of the light and reflected another part of it. Then H. A. Lorentz in 1895 showed that Fizeau's formula was too simple, and that there should be a third term, ϵ being $1 - \frac{1}{\mu^2} - \frac{1}{\mu}\frac{d\mu}{d\lambda}$. But that formula—which really means that we measure the Doppler change in period for an artificially-produced velocity—would yield a theoretical displacement of 0.451 for the D line (instead of Fizeau's deduced value 0.404), so that the experimental agreement was less satisfactory than it had appeared. For this and other reasons Weinstein and Jaumann suggested a modification of the formula, and P. Zeeman, the discoverer of the Zeeman effect, has once more repeated the experiments, not with white light, but with monochromatic light of different wave-lengths—namely, the yellow, green and violet mercury lines or arc light passing through a slit. He adopted the general arrangement of Michelsen and Morley, but wider tubes; his account of the mechanical details of his apparatus in the Proceedings of the Akad. Wetenschappen, Amsterdam, vol. xvii., page 445, 1914, and vol. xviii., page 398, is very brief. He used Hilger lenses; his water velocity (measured by means of a Woltmann meter) was about 465 cm. per second, and the water moved under a pressure of 2.14 kg. per sq. cm. The fringes were recorded photographically, and Zeeman made his measurements on the negatives which are reproduced in his memoir. The results may be summarised as follows:—

Wave-Length.	Displacement Calculated.		Displacement Found.
	Fresnel.	Lorentz.	
4500	0.443	0.464	0.465
4580	0.442	0.463	0.463
5461	0.439	0.454	0.451
6870	0.435	0.447	0.445

The accord is thus very good, and the experiments decide in favour of Lorentz's formula.

Illusions of the Upper Atmosphere.

The discourse on "Illusions of the Upper Atmosphere," which Sir Napier Shaw, F.R.S., Director of the Meteorological Office, delivered at the Royal Institution last Friday, may have been a surprise to some members of his audience, who possibly expected to hear something about mock-suns, halos, or auroræ, or the strange experiences of aeronauts. Apart from historical notes, Sir N. Shaw confined himself practically to old and new views as to the circulation of the air under cyclonic and anti-cyclonic conditions. He pointed out that half-a century had just elapsed since the Meteorological Committee of the Royal Society had taken control of the Meteorological Department, and that a British Association Committee had also collaborated with the Department. Reviewing the progress of meteorological theory in England in that half-century, Dr. Shaw remarked that the first programme of the reconstituted office had been the meteorology of the sea, for the benefit of shipping and of the general public, rather than the meteorology of the land for the benefit of agriculture, as on the Continent, and that rainfall and climatology had been left to the private enterprise of G. J. Symons, James Glaisher, and others. The term "anti-cyclone," for an area of high pressure—or a "high," in the American phrase, as distinct from a cyclone, or a "low"—had been introduced by Francis Galton; and Galton's convection theory had generally been accepted in an age which knew very little about the upper atmosphere, and could hence speculate all the more. Briefly speaking, an anti-cyclone had been considered as an area of cold currents descending from the higher strata and flowing out in all directions near the earth's surface, whilst in a cyclone warm currents had been supposed to converge and to rise, the straight flow of the air from the cold to the warm centre being deflected by the rotation of the earth and turned into a spiral flow. The investigation of the upper air by means of balloons and kites, and especially of unmanned balloons (*ballons sondes*), had proved this view to be illusory. It was not easy to understand in the first instance how the spiral convergence to a definite centre was to be maintained when the whole system was moving. Then it had been proved that the inflow towards a low-pressure centre could not be identified at all at heights of more than ½ km. above the surface level. The temperature, moreover, did not go on decreasing to the zero of space as one ascended higher and higher. The more or less horisontal isothermals near the earth's surface became nearly vertical at about 10 km. height in the so-called isothermal layer, and one had to move horizontally, not vertically upward, in the higher atmosphere to meet with colder air. Modern meteorology distinguished the troposphere near the earth, the isothermal layer, and the stratosphere above the latter. Since we were living at the bottom of the troposphere, it was not surprising that its influence had been overestimated. But the whole atmosphere had to be considered. The circulation really seemed to be represented by the uniform flow along the isobars under balanced forces arising from the distribution of pressure on the one hand, and the rotation of the earth and the circular path of the air on the other. The flow—as the chart of the gale of November 12-13, 1915, proved, for instance—was by no means a natural flow from high to low pressure, but it took place without change of pressure, like the motion of a planet round the sun, not like a falling stone. The cross-flow observed near the surface was to be attributed to the friction of the air against the earth, and this friction was not an obstacle to the cross-flow, but its cause. The air above a high-pressure area was not colder, but really warmer, than that over a low pressure area at the same level, and the formation of high and low pressures at the surface proceeded in spite of an opposing temperature distribution, not because of it. The distribution of the pressure at the surface was shown to be the distribution at a height of 9 km. transmitted from above with local changes caused by the varying density of the lower layers. The atmospheric humidity was not of any importance in forming low pressures; but the study of the formation and transformation of different types of clouds was very instructive. In numerical calculations concerning pressure and wind velocity two relations could be considered: the geostrophic relation regarding the air as moving along a great circle (applicable probably to temperate and polar zones), and the cyclostrophic relation, which disregarded the rotation of the earth and concentrated its attention upon motion in a small circle (applicable to the equatorial regions, tropical revolving storms, and local disturbances). By means of these relations and observed facts many meteorological phenomena could be explained. But Sir Napier Shaw did not fail to add that his theory might prove another "illusion."

Lockwood's Builder's and Contractor's Price-Book, 1916.—This price-book, which is issued by Messrs. Crosby Lockwood and Son, 7, Stationers' Hall-court, Ludgate-hill, E.C., at the price of 4s., is edited by Mr. R. Stephen Ayling, Fellow of the Royal Institute of British Architects, Member of the Royal Sanitary Institute. It gives detailed prices for all classes of material and labour employed in the construction of buildings; it indicates also the British districts in which any particular product, such as limestone, sandstone, &c., is found, and describes the characteristic features of such products and the conditions in which they are obtainable. The book allows of establishing the cost of any building scheme and checking the work in cost of construction. It contains also a number of useful tables and memoranda, and the Building Acts, Bye-Laws, and other enactments applicable to the specialties dealt with. It is completed by a detailed index.

Grand Trunk Pacific Railway.—The Grand Trunk Pacific Railway has cost 355,000,000 dols. in round figures. The Lake Superior division of the Grand Trunk Pacific was taken over by the Canadian Government in July, 1915, under a lease, and it is now being worked as part of the National Trans-Continental Railway. The rent to be paid is 600,000 dols. per annum. The Grand Trunk Pacific system now stops at Winnipeg. Hitherto it extended virtually to Fort William *viâ* the Lake Superior division, the intervening National Trans-Continental link between Graham and Winnipeg having been used by the Grand Trunk Pacific under a lease from the Government. All lines east of Winnipeg are now being worked by the Canadian Government, the Grand Trunk Pacific eastbound traffic at Winnipeg being taken over by the Trans-Continental system. Construction work on the Grand Trunk Pacific was restricted last year to ballasting and bridging, principally on the mountain division, and no new extensions have been undertaken. The company has adopted oil fuel on its locomotives between Prince Rupert and McBride, and oil-fuel plants have been completed at Jasper, McBride, Prince George, Endako, Smithers, Pacific, and Prince Rupert, the last-mentioned having facilities for unloading from ships and loading cars for shipment inland. An oil-dock at Prince Rupert and a bridge to the oil-tanks were also completed. Passenger-train service between Edmonton and Prince Rupert has been augmented in consequence of increasing travel and many visitors to and from the Panama Exposition. The length of the Canadian Pacific is returned at 3544 miles, exclusive of branches. The eastern division, built by the Dominion Government, comprises 1800 miles.

INDUSTRIAL NOTES.

THE Director of the Department of Labour Statistics states, in the *Board of Trade Labour Gazette*, that with reference to the labour market, in February the high level of employment was fully maintained, and the percentage of unemployed among the trade-union members was the lowest ever recorded by the department. Owing to the number of male workers now in the Forces, the labour requirements were not being met, and special steps were now being taken to increase the number of women workers both in industry and agriculture.

The war bonuses and increases in rates of wages reported as taking effect in February affected over 204,000 workpeople, and amounted to about 12,500*l.* per week. The principal changes affected 120,000 coalminers in Durham, 20,000 iron puddlers and millmen in the Midlands, and 14,000 workpeople in woolsorting and combing establishments at Bradford.

The number of disputes beginning in February was 38, and the total number of workpeople involved in all disputes in progress was 12,831, as compared with 11,697 in the previous month, and 31,060 in February, 1915. The estimated total aggregate duration of all disputes during the month was 102,600 working days, as compared with 97,600 in January, 1916, and 208,600 in February, 1915.

The average weekly number of vacancies notified to all labour exchanges for the four weeks ended February 11 was 45,948, as compared with 31,572 in the five previous weeks, and with 34,006 in the four weeks ended February 12, 1915. The average weekly number of vacancies filled for the same periods was 28,902, 23,352, and 24,966 respectively.

The special arbitration tribunals which the Minister of Munitions is empowered to constitute by Section 8 of the Munitions of War (Amendment) Act, 1916, have now been set up. These tribunals will deal with differences arising in connection with the exercise of the powers given to the Minister by the new Act in respect of the wages, hours, and conditions of employment of women or of semi-skilled and unskilled men. Under Section 6 of the Amending Act, where female workers are employed on or in connection with munition work in establishments in which leaving certificates are necessary, the Minister has power by order to give directions as to the rate of wages, as to the hours of labour, and as to the conditions of employment of these female workers. The special arbitration tribunal to which differences relating to these matters may be referred has been constituted as follows:—Mr. Lynden Macassey, K.C., chairman; Mr. Ernest Aves, Mr. F. S. Button, Miss Susan Lawrence, Mr. Allan M. Smith, and Mrs. Streatfield.

Under Section 7 of the Amending Act the Minister may by order give directions as to the rate of wages or the hours of labour or the conditions of employment of semi-skilled and unskilled men employed in a controlled establishment on munition work of a class which before the war was customarily undertaken by skilled labour; and in the same way he may give directions as to time-rates paid for the manufacture of complete shell and fuses and cartridge-cases in a controlled establishment in which this manufacture was not customary before the war. The special arbitration tribunal to deal with differences arising in connection with these matters consists of:—Mr. Lynden Macassey, K.C., chairman; Mr. Charles Duncan, M.P.; Mr. W. H. Hutchinson, Mr. Allan M. Smith, and Mr. J. C. Ward.

An additional function of each of these tribunals is to advise the Minister, on being consulted by him, as to what directions he should give in respect of the matters specified. The chairman and three other members of the tribunal form a quorum, and in the case of equality of voting the chairman has a second vote.

The occupations "starred" at the time of the National Register included those essential for the manufacture of munitions of war, together with certain skilled occupations in agriculture. Workers in coalmines, on the railways, in the mercantile marine, and in the public utility services were also treated as essential to the carrying on of the national life. In addition, many workers actually engaged on war work were badged. Altogether the men referred to above are estimated to account for four-fifths of the number of men of military age exempted from military service. The remaining fifth (known as List D) is made up of various occupations reserved in trades largely connected with exports. The reservations in this list were recommended by the Reserved Occupations Committee, and approved by the Army Council. For some time past a representative of the War Office has been a member of the Committee.

Recently this Committee has been asked to undertake the revision not only of their own fifth of the exemptions, but also of the other four-fifths, except as regards railways and coal-mines. To do so it was necessary to secure the co-operation of the other departments concerned. Representatives of these departments were accordingly added, and the Committee now consists of officials of the following departments:—Admiralty (1), Board of Agriculture and Fisheries (2), Board of Trade (2), General Register Office (1), Home Office (3), Local Government Board (1), Ministry of Munitions (2), War Office (3).

This Committee will report to a Sub-Committee of the Cabinet which has been set up under the chairmanship of Mr. Walter Long, to supervise the whole question of exemptions. The Reserved Occupations Committee has already reviewed the exemptions for which it was originally responsible, and the following recommendations have been considered and approved as regards this List (D):—

1. As evidence has accumulated to show that men have been entering certified occupations in order to avoid military service, it has been decided that men in these occupations will be exempted from military service only if they can show that they were similarly occupied at the date when the National Register was made—August 15, 1915.

2. With the same object of preventing abuse of necessary reservations, it has been decided as far as possible to limit exemption of those claiming to hold positions implying considerable experience and responsibility, such as departmental managers, foremen, overlookers and the like, to married men aged thirty or over.

3. It has been decided very generally to limit the scope of the reservations by releasing for service with the Forces unmarried men up to the age of twenty-five or thirty, or, in some cases, up to forty-one. Only in those occupations which are vital to the conduct of the war, and where the evidence against any depletion is overwhelming, will the younger unmarried men be retained on the reserved list. In determining this question the possibility of substitution by males of non-military age or by females has been constantly kept in mind, as, indeed, it has been throughout.

4. It has further been decided to delete from the list of reservations the occupations connected with certain industries. Thus luxury trades, such as the manufacture of tobacco, silk, and lace, which have received protection merely because of the importance of their exports, have been struck out of the list. The revision of the lists of exemptions as affecting munitions, agriculture, and mining, is in progress, and a statement on the subject will be issued shortly. Meantime the Ministry of Munitions and the other Departments concerned are proceeding, through their Inspectors, actively to revise the present lists of holders of War Service badges, with a view to the withdrawal of exemptions no longer necessary.

The report, dated March 8, issued by the Steam-Engine Makers' Society states that trade still continues good, and the demand for the services of members, notwithstanding the schemes for dilution, far exceeds the supply. Much concern and anxiety still exists in the minds of many members as to whether the nature of the safeguards set out in the recent emergency legislation adequately protects the operative engineer on the termination of the war. There is no doubt whatever, says the report, but that provision is made in the War Munition Act, 1915, to compel employers at the end of the war to restore pre-war conditions. The report then states the opinion expressed by the legal adviser to the Ministry of Munitions as to the "obligations of employers under Schedule II. of the Munitions of War Act," and adds that not only does the Act adequately safeguard the position of the operative engineers when peace is restored, but makes it possible for action to be taken against any employer who fails to restore trade-union conditions after the war.

The following letter is contained in the report, written by Mr. William W. Atkinson, branch secretary, Birmingham:—

"Fellow-Members,—The Birmingham members of the Steam-Engine Makers' Society desire to place on record their abhorrence of the methods of warfare practised by the German Government, especially in relation to submarine and aerial attacks on non-combatants.

"Their determination, individually and collectively, is to do all in their power to bring success to the Allied arms.

"They deprecate all premature talk of peace, and are prepared to protest, politically and industrially, against any termination of the war other than by the complete destruction of Prussian militarism."

The novel experiment which has been made with regard to women dock labourers at Liverpool will go down to posterity as the experiment that failed, says the *Liverpool Courier*. At least, that is the earnest hope of those who labour at the docks.

It appears that about forty women were taken on last Friday by one of the shipping companies, and were given the work of trucking cotton in the upper storey shed. At first the men were so surprised at the innovation that they hesitated about forming a judgment. But during the week-end they hit upon a resolution which they put into force in a practical fashion on Monday morning. When they arrived at the docks, they passed the word along through the proper channels that they would not work with the women. They were prepared to give way to them, but they declined to work alongside them, for a multitude of reasons.

The dockers' ultimatum came as a surprise to the employers, who thought there could be no possible objection to women coming to the docks to do their little bit in the nation's service. However, there was no alternative for them, and so the women had to go.

Mr. James Sexton, the general secretary of the Dockers' Union, when interviewed on the matter, said:—"I hope there will be no more attempts made to introduce this kind of labour at the docks without full consultation with the union as to the necessity or otherwise for such a step. The work is not suitable for women—not even those of the roughest type—while the sanitary arrangements, when the workers are of different sexes, are perfectly abominable. The surroundings are not nice, and are far from being in keeping with what the average docker regards as decency. I do hope that we have heard the last of the woman docker under the existing circumstances.

"Has the union taken any official action in the matter?

"Certainly, we took prompt action. Our executive on Monday passed a resolution protesting against the introduction of female labour at the docks, and that resolution was sent to the Employers' Association."

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this Society was held on Wednesday, the 15th inst., at the Surveyors' Institution, Great George-street, Westminster, Major H. C. Lyons, D.Sc., F.R.S., President, occupying the chair.

Sir Napier Shaw, Sc.D., F.R.S., delivered a lecture on "The Meteorology of the Globe in 1911," of which the following is an abstract:—

"The year 1911 is still remembered for its fine warm summer. A correspondence in *Nature* was opened by Sir Edward Fry with a challenge to meteorologists to produce the reason for it. Then, as always, the discussion meandered for awhile and lost itself in the desert owing to want of facts, not because of the lack of facts. The Committee of the Meteorological Office authorised the preparation of an annual statement of the Meteorology of the Globe, beginning with 1911, not only because of the want of facts, but as the sequel of a long series of discussions at meetings of the International Meteorological Committee and its Commissions, the International Solar Commission, the International Commission for Maritime Meteorology and Storm Warnings, the International Commission for Réseau Mondial, as well as the Solar Physics Committee of the Board of Education, which, through the Solar Physics Observatory at South Kensington, was concerned with the relation of solar and terrestrial phenomena, especially rainfall. The volume for that year is now nearly ready for issue.

"It gives particulars of pressure, temperature, and rainfall for available stations in all parts of the globe at the rate of two stations for each 10-deg. square of latitude and longitude. It also gives the differences from the normal in those cases in which normals existed or could be compiled.

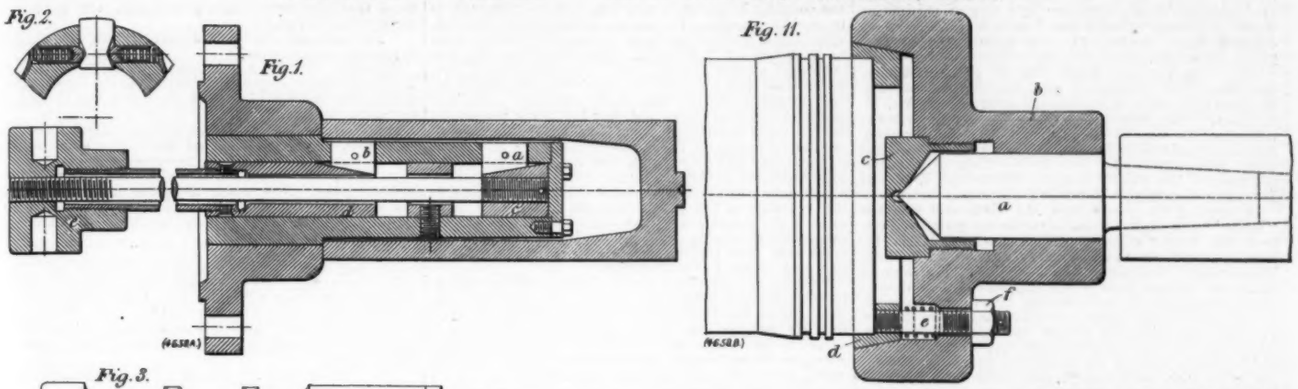
"The number of stations is 390 for a total of 576 squares, omitting the regions beyond 80 deg. north and south. The names of many are quite unfamiliar to the general reader, but the selection is interesting on account of the number of stations in British possessions which are for the first time adequately represented in a general meteorological summary.

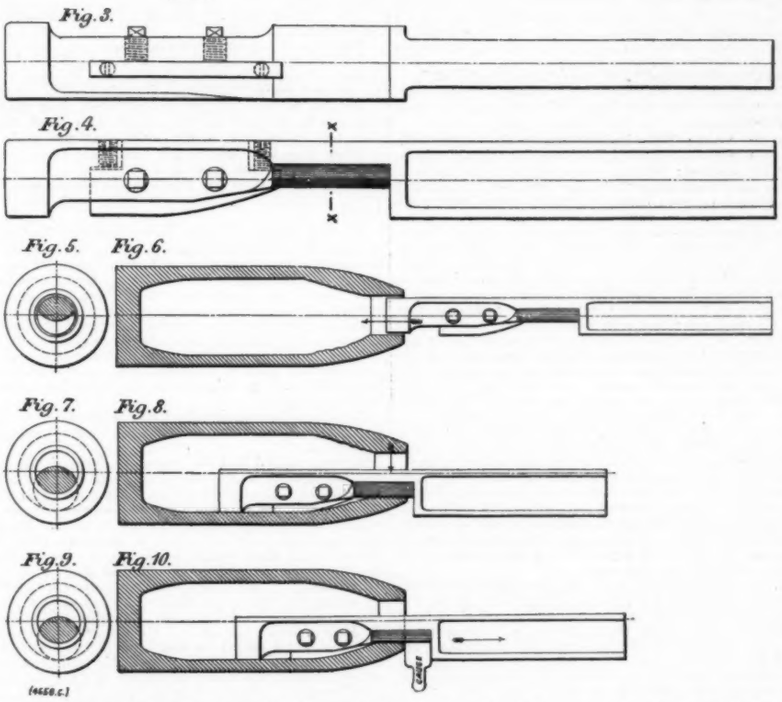
"The values are given in absolute units for pressure and temperature. Positive and negative signs are therefore only used to indicate differences from normal, except in two cases of negative sign in the column for height, which indicate that the stations are below sea-level. A brief discussion of the meteorology of the year is based upon the differences from normal."

THE LATE DR. P. CHAPPUIS.—Dr. Pierre Chappuis, for many years one of the best-known members of the Bureau International des Poids et Mesures at Sèvres, died at Basle, in Switzerland, on February 15, in his sixtieth year. He was born in Switzerland, and had returned to his native country when resigning his appointment at Sèvres in 1903. This post he had accepted in 1881, when J. O. Broch was director of the bureau. Chappuis had the reputation of being an exceedingly careful experimenter, and his work on gas thermometry in particular has made him famous among scientists. His determination of the expansion coefficients of water and of mercury were cognate tasks which he undertook; one of his other researches concerned the determination of the volume of the kilogramme of water by the optical method of Benoit—now director of the bureau—and of Michelson. At the time of his death he was still engaged in a memoir upon his redetermination of the boiling-point of sulphur, one of the fixed points for high-temperature thermometry. In Switzerland he was known as Chappuis-Sarasin, the second name being that of his wife. Dr. Chappuis attended the British Association meeting at Dover in 1899. He leaves many friends.

CHUCKS AND TOOLS FOR SHELL-MAKING.

CONSTRUCTED BY MESSRS. J. AND H. McLAREN, ENGINEERS, LEEDS.





AMONG the many engineering firms in this country who have turned their attention to the production of war material are Messrs. J. and H. McLaren, of the Midland Engine Works, Leeds. As is well known, this firm specialises in the manufacture of steam ploughing-engines and other agricultural machinery in normal times, whereas the whole of their machine-shops are now occupied in making more than forty different types and sizes of special chucks and other tools for machining high-explosive shells of 3.3-in. calibre and upwards. These tools, of which we illustrate a selection on the present page, are adapted for all the various operations, from the centring of the forging to the completion of the shell, and the makers claim that their employment greatly increases production, so that piecework prices can be considerably cut down without reducing the workers' earnings. We understand that the tools have been supplied in large numbers to most of the national shell factories, as well as to the large armament firms.

Fig. 1 is a longitudinal section of an expanding mandrel, used for facing and centring shell forgings, one of which is shown in position on the mandrel. This appliance, and all others of a similar nature, is bolted to a special adapter flange screwed on to the lathe spindle. The body of the mandrel is provided with two sets of three hardened steel jaws a, b, which project slightly through slots in the body, and have tapered backs resting in corresponding grooves cut in cylindrical plugs c and d which are capable of sliding inside the body. These plugs are connected by a rod and tube, which pass through the hollow spindle of the lathe, to a nut e. As the rod is screwed with a right-hand thread, and the tube with a left-hand thread, the effect of tightening up the nut is to pull the plug c and push the plug d inwards towards the middle of the mandrel, and thus force the jaws radially outwards, so that they grip the interior of the shell forging. The jaws are each prevented from falling out by a pair of spring buffers which are shown to a larger scale in Fig. 2. In the course of manufacture these mandrels are all tested to a limit of 0.002 in., and the tops of the hardened jaws are finally ground in position to the same limit.

Figs. 3 and 4 are respectively a side elevation and plan of a blending tool for finishing the curved internal surface near the nose of a shell after the nose has been formed by a process known as "bottling." The shell forging as first produced is of the form shown on the mandrel in Fig. 1, and after being partially machined it is reheated and pressed in a bottle-shaped die to the form illustrated in Fig. 6. This operation, of course, distorts the internal surface, as indicated in the drawing, and the tool we are now dealing with is used for removing the distortion and forming the correct curvature, the operation being known as "blending." The blending process is carried out on an ordinary lathe, with the tool illustrated in Figs. 3 and 4, clamped in the slide-rest, the shell forging being held on the outside in another of Messrs. McLaren's special chucks. The shape of the holder is well shown in these illustrations, and it is only necessary to mention that the section of the metal at the neck, marked X X, in Fig. 4, is of the form indicated by the cross-hatched portions of Figs. 5, 7, and 9. A suitable form-cutter is clamped in the holder by two set-screws, and its position can be adjusted by two grub-screws as shown. The three stages in the process of blending a shell are illustrated in Figs. 5 to 10. The tool is first inserted through the hole in the nose of the shell, as indicated in Figs. 5 and 6, and then brought forward into the position shown in Figs. 7 and 8. In this position it will be noticed that the end of the holder and the cutter are in contact with the interior of the shell, and the neck of the holder bears against the periphery of the hole in the nose, so that the tool is effectively guided and prevented from penetrating too deeply. The tool is then moved to the right until a gauge can be just inserted between the nose of the shell and the rectangular part of the holder, as shown in Fig. 10, which indicates that the operation is finished; the tool is then moved back and withdrawn.

One of the last operations in machining a shell is the turning of the copper driving-band, but before it has reached this stage a base-plug has been fitted, so that the original centre in the base has been lost. It is therefore necessary to employ a temporary centre, and it is obviously most important for the shell to run absolutely true during the process of band-turning. To meet these conditions, Messrs. McLaren have devised the arrangement illustrated in Fig. 11, which they call an "adapter centre." With this device it is necessary to replace the ordinary back centre of the loose headstock with a special centre a, on which the body b of the adapter is a running fit. A hardened-steel centre piece c is screwed into the body of the adapter, with a left-handed thread, for the centre a to bear against. The body b is also cored to fit a spring collet d, which is bored internally to take the end of the shell, as shown in Fig. 11. The collet is held in the body by means of three studs, one of which, lettered e, is shown in the drawing, and each of the studs is fitted with a small helical spring, which tends to force the collet-ring outwards. To chuck a shell the nuts f on the studs e are slacked back, so that the collet moves outwards and opens sufficiently to receive the shell, and after putting the shell in place, the centre is brought up by turning the hand-wheel of the loose headstock a little, so that the shell is held lightly between the lathe centres. The lathe is then set running, and the back centre slowly tightened up by the hand-wheel to allow the shell to find its own centre. After stopping the lathe, the hand-wheel is tightened up as much as possible to cause the collet-ring to grip the shell tightly, and the three nuts f are then tightened up, with the finger and thumb only, to retain the grip. After slacking back the hand-wheel to make the centre a proper working fit, the turning of the copper band can be proceeded with. When finished the shell is removed by first tightening up the centre as much as possible to take the pressure off the nuts f, so that they can be slackened easily, and then slacking back the centre with the hand-wheel. The object of the sequence of operations described for inserting a shell is, as already mentioned, to allow the shell to centre itself, and also to equalise the pressure on the collet-ring; it is hardly necessary to point out that they take almost as long to explain as actually to carry out.

Among the other tools and accessories for shell-making now being manufactured by Messrs. McLaren are a waving attachment for use on ordinary screw-cutting lathes, a machine for stamping numbers and other marks on the bases of shells, and bottling dies for forming shell-noses in the manner mentioned in our description of the blending-tool.

INDIAN LIGHT RAILWAYS.—Official sanction has been granted for carrying out reconnaissance surveys for a system of light railways or tramways branching out from Kalagarh into the Patli, Dun Palain, and Sonanadi valleys, in the Lansdowne and Ramnagar forest divisions.

KIER EXPLOSION AT BURY.

A FORMAL investigation by the Board of Trade under the Boiler Explosions Act, 1882, has been conducted at the Council House, Bury, with regard to the cause and circumstances of the explosion of a kier at the bleach works of Messrs. Spencer and Curedale, Limited, Bury Ground, Bury, on July 30, 1915, when four men were killed and several others injured.

The Commissioners were Mr. F. Sims Williams, barrister-at-law (presiding), and Mr. A. J. Maginnis, M. Inst. C.E., M.I.M.E., consulting engineer. Mr. G. C. Vaux, of the Solicitors' Department, Board of Trade, presented the case to the Court; Mr. C. H. Pickstone, solicitor, appeared for Messrs. Spencer and Curedale and their workpeople, and Mr. J. W. Robson, solicitor, represented the British Engine, Boiler and Electrical Insurance Company, with whom the kier was insured.

In opening the proceedings, Mr. Vaux said that the "boiler" that exploded was a revolving cylindrical kier used for boiling cotton-waste in caustic solution for bleaching purposes. It was made in 1884 by James Jones, boiler-maker, Stockport, who had since died, and in November of that year it was supplied new to Messrs. Hall, bleachers, of Whaley Bridge, by whom it was sold, in 1895, to Messrs. Spencer and Curedale, who fixed it at their works, and used it until the explosion occurred. At the time of the explosion there were two kiers in use, and both were insured for a working pressure of 20 lb. per sq. in. with the British Engine, Boiler and Electrical Insurance Company, Limited. The kiers were described in the policy as "Nos. 3 and 4," and it was No. 4 which formed the subject of the investigation. Mr. Vaux gave full details of the construction and various fittings, and said that the steam was generated in a Lancashire boiler, the safety-valves of which were loaded to a pressure of 110 lb. per sq. in. Prior to 1913 steam was admitted to the kiers through two reducing-valves, with a safety-valve loaded by means of a lever and weight on the reduced-steam side, there being a small dead-weight safety-valve on the steam-trunnions on each kier. In July, 1913, owing to the reducing-valve getting out of order, a new reducing-valve was obtained from Messrs. Stuart and Co., of Belfast, in order to reduce the pressure from 110 lb. to 20 lb.; the two old reducing-valves and the lever safety-valve were done away with, and the new combined safety-valve took their place. The reducing-valve was set by someone at the works to reduce the pressure to 20 lb., and, when first tried, Mr. Spencer, the manager, appeared to have satisfied himself that it was working properly. The dead-weight safety-valves on the kiers were retained, and no other alterations were made. In October, 1912, the kier in question was tested by hydraulic pressure to 40 lb. by Messrs. Lord, boiler-makers, of Bury, the test being said to be satisfactory. In April, 1915, the dead-weight safety-valve on No. 4 kier (the one which subsequently exploded) was said to have been overhauled and cleaned by workmen in the firm's employ, and no repairs of any importance appeared to have been done. The kier was insured with the British Company in 1908, and Mr. Vaux gave full particulars as to the inspections which had been made by that company. In September, 1913, after an inspection of the kiers, the insurance company wrote: "It is imperative that every care should be taken to test the combined reducing-valve, regulating the pressure from 110 lb. to 20 lb., for should it get out of order, we are afraid the dead-weight safety-valve would not have sufficient area to prevent pressure accumulating to a dangerous degree." On October 13, 1913, Messrs. Spencer and Curedale replied that they had added a safety-valve to the reducing-valve. In reporting on the inspection made in April, 1914, the insurance company drew attention to the necessity of seeing that the combined reducing and safety-valve was kept in efficient order, and in November, 1914, attention was drawn to the advisability of keeping the pipe leading to the safety-valve clear. On June 21, 1915, Mr. Hinson, one of the insurance company's inspectors, made an examination of the kiers, No. 4 being at rest, and he noticed that the pressure-gauge on the reducing-valve on the low-pressure side registered 30 lb., and at once concluded that something was wrong. The insurance company wrote to Messrs. Spencer and Curedale on June 29, 1915, that either the pressure-gauge serving that and No. 4 kier was incorrect, or the combined reducing and safety-valve needed overhauling, as a pressure of 30 lb. was indicated at the time of the inspector's visit, although the vessels were insured at 20 lb., and that they understood that the matter would have attention. New steam-gauges were ordered by Mr. Spencer, but were not delivered before the explosion occurred. About the end of June or the beginning of July, 1915, the pipe of the dead-weight safety-valve on No. 4 kier was taken off by Howarth, the foreman, who appeared to have looked into it, and to have removed some pieces of fluff. He also pushed a stick up the pipe and seemed to have come to the conclusion that it was clear. Just before the explosion occurred on July 30, the steam pressure on the Lancashire boiler was 105 lb. The explosion occurred at 6.30 p.m., No. 4 kier being torn into a number of pieces, which were scattered about the works for varying distances up to 150 ft.; No. 3 kier, weighing about 7 tons, was lifted bodily and projected about 22 ft.; the works were wrecked, four men were killed, and fifteen more or less injured.

Mr. Vaux then proceeded to call evidence, the first witness being Mr. William Spencer, who said he as a director of Messrs. Spencer and Curedale, Limited, and had been connected with the firm for nearly thirty-four years. He had no engineering knowledge except what he had gathered in the business. No repairs had been made to the kier, and a steam pressure of 20 lb. was enough for their process, and there was no advantage in extra pressure. They did not rely on the combined reducing-valve except as a sentinel to give warning; they relied on the dead-weight safety-valve. The combined valve had not been interfered with from the time of being purchased up to the time of the explosion; he did not consider it necessary to overhaul it, as it seemed to be working all right. On the day the explosion occurred, witness had received no report or complaint from anyone as to things not going right. The loss to his firm was estimated at 4000*l.*, but it would be more than that. Up to the time of the visit of the Board of Trade officials he had no idea as to the cause of the explosion. The kier had been blown to pieces, and they had found practically all the parts except the spring safety-valve attached to the reducing-valve. The dead-weight valve was found to be choked up with packing, fluff, lime, &c., and in the pipe which led to the valve there was a piece of packing about 3 in. long and ¼ in. thick. The pipe leading to the entrance of the gauge was also choked. Witness came to the conclusion that the explosion was caused by the safety-valve being choked up, and the reducing-valve must have been passing more steam, so that the explosion was caused by over-pressure.

Witness was questioned by Mr. Vaux as to the reports from the insurance company, and said it was his duty to look at them and give recommendations to be attended to. He received the letter which stated that "care should be taken regularly to test the combined reducing-valve, as, should it get out of order, the dead-weight valve would not have sufficient area to prevent steam accumulating to a dangerous degree." After the receipt of that letter, witness said they took special precautions to prevent fluff getting into the pipes.

The Commissioner: "Did you ignore the advice?"

Witness: "Yes, we did not put a bigger valve on." They received other warnings, and had given an order for new gauges.

By Mr. Vaux: They had no one at the works with sufficient technical knowledge to overhaul the mountings.

By Mr. Robson: When he received the insurance company's reports about the valves, he gave instructions that they should be kept clear. About a month before the explosion he got the impression for the first time that the pressure-gauge was working too fast.

By Mr. Pickstone: Witness said they took means to prevent an explosion of the kier, as they had a dead-weight safety-valve, a reducing-valve, the sentinel valve, pressure-gauge, &c. In addition, they had the personal inspection of the kier by the insurance company, and with all these precautions he thought they were reasonably safe. The whole of the recommendations in the later reports by the insurance company were not carried out because he thought they were not necessary. He could not disabuse his mind of the fact that the dead-weight safety-valve had acted successfully for many years. He had no reason to think it was too small.

In reply to Mr. Maginnis, witness stated that when steam was shut off, the pressure in the kier would force water carrying fluff and packing into the safety-valve.

Mr. J. C. Stuart, of the firm of J. C. Stuart and Co., Belfast, by whom the combined reducing and safety-valve was supplied, gave evidence, and said that it was desirable that valves should be overhauled and examined at least every twelve months; any defect caused by the steam or the action of any chemical properties in the water would then be discovered.

Mr. Herbert G. Dixon, engineer-surveyor to the Board of Trade, presented a report as to the cause of the explosion, and the result of an examination he had made of the exploded kier. The plates showed no sign of corrosion, and were practically their original thickness. He found the reducing valve in a defective condition, and it must have been leaking badly for some considerable time before the explosion. It might have reduced the pressure a little, but its condition would have allowed a high pressure of steam to pass through. The pipes and cock of the steam-pressure gauge leading to the reducing-valve were choked with dirt, and he did not think any steam could get through; the gauge could not register the correct pressure. The condition in which he found the valve would prevent its working, and the 1-in. vertical pipe leading to the dead-weight safety-valve was choked with dirt and packing. Witness was of the opinion that the cause of the explosion was excessive steam pressure.

Mr. John Thompson, engineer-surveyor to the Board of Trade, confirmed the evidence of the previous witness, and Mr. W. H. Berry, of the boiler department of the insurance company, gave evidence with regard to the insurance of the kier.

Mr. Ernest Manning, assistant-engineer to the British Insurance Company, gave details of the various inspections made of the exploded kier, and of the reports sent thereon. At the last thorough examination of the kier, made in August, 1914, the dead-weight safety-valve was not examined internally—that is, opened out and inspected; the inspector reported it as "in order as seen." Judging from the reports, the valve had not been opened from August, 1912, but it would have been better if it had been opened.

Mr. Maginnis here pointed out that the proper working of the safety-valve was absolutely necessary for the safe working of the kier, and the inspector should have asked to have had the valve opened.

In reply, witness agreed that it only meant the unscrewing of three nuts; but they could not even get that done at holiday times.

Mr. Maginnis said it was very vague for the inspector to report the "valve in order as seen," because he could see nothing at all if it was not opened.

The Commissioner: "The report 'In order as seen' meant that, so far as he could tell without it being opened, it was in order?"—"Yes."

"Then you understood the inspector had not carried out a thorough examination of the dead-weight valve?"

Mr. Maginnis: "You see the risk that applied at any time to that kier; it could have the full boiler pressure, but no sufficient means to take it away."—"I understood that the safety-valve attached to the reducing-valve was sufficient."

"You regarded the dead-weight safety-valve sufficient to prevent an explosion?"

Witness: "I did not look upon it in that light; I took it that the dead-weight safety-valve and the safety-valve attached to the reducing-valve were sufficient to reduce any undue pressure."

Mr. Maginnis: "In this case you have allowed a vessel to be used—you have accepted the risk—a vessel which can be supplied with 110 lb. pressure of steam from a 1½-in. pipe, with only a 1-in. safety-valve to take the pressure away. Now under these circumstances do you not consider that the accumulation would be so rapid that it would be impossible for the safety-valve to let that pressure away?"

Witness: "Certainly, if it is 110 lb."

Mr. Maginnis: "It is a well-known fact that reducing-valves, even the newest, are sometimes not reliable, so that had there been a 2-in. or 3-in. safety-valve, the explosion could not have taken place?"

Witness replied "No," but added that safety-valves were usually placed on the low-pressure side of the reducing valve.

The Commissioner: "You agree that the dead-weight valve was not adequate?"

Witness: "I quite agree with that."

Mr. Maginnis asked when it was reported that the gauge showed 30 lb. working pressure. Witness did not appear to have inquired what the safety-valve was doing.

Witness replied that he was informed that the valve was not blowing off, and this made him think himself that the gauge was wrong. On examination, it was evident that the dead-weight valve was out of order. With regard to the packing found in the pipe, it would be squeezed out when the pipe was screwed up, and pieces would be carried by steam or water to where it was found.

By Mr. Vaux: Witness knew that the dead-weight valve had a diameter of 1 1/16 in., but he did not know that the safety-valve attached to the reducing-valve was only ¼ in., or he would not have passed it. He was misled by Mr. Mason, the inspector, stating that the valve was sufficient to take any undue pressure.

Mr. J. J. McGough, formerly inspector with the insurance company for over thirty years, who said he retired on pension in January, 1915, gave evidence as to examinations he had made of the exploded kier. It was not an inspector's duty to take valves to pieces, but to ask for this to be done.

The Commissioner inquired why witness did not state in his report that the valve had not been opened for his inspection.

Witness replied that the statement, "in order as seen, was understood at the office to mean that a thorough examination had not been made. The opening of valves was not such an easy matter as was supposed, especially when a ladder had to be used to get to them. He made his last report in January, 1915, when he was quite satisfied with the dead-weight safety-valve. He never saw the dead-weight valve opened out after August 12, 1912.

Practically between two and three days were occupied by taking evidence from various men in the employ of Messrs. Spencer and Curedale, after which Mr. Charles E. Mason, boiler inspector for the insurance company, was called, and stated he had been in the employment of the firm for about sixteen years. He made a thorough examination of the boiler and kiers at Messrs. Spencer and Curedale's works in August, 1913, and gave in detail particulars of his practice when making inspections, and of what constituted a thorough examination. If the boilers were at rest and the mountings not opened up, he would take what the persons in charge stated as to their condition, and would report that the examination had been made "as far as practicable." When he visited Messrs. Spencer and Curedale's works he examined No. 4 kier, and his report thereon stated "examined fully as far as practicable." He examined the kier at rest, but the fittings were not opened up for inspection. He stated in his report that he was told that the safety-valve was in order by a man who said it had recently been taken off and cleaned; the man might have been a labourer.

The Commissioner: "Were you sent there to get information from a labourer?"—"To get information from anyone I could."

"But a gentleman of your experience is not sent to get information; you are intended to make an examination."—"I am certainly not intended to take off safety-valves."

"You stated as a fact that the safety-valve was in order?"—"As far as I could see."

"But you did not state 'as seen;' you could not see anything. The words 'in order' simply meant somebody said it was?"—"Yes."

"Then your company send a report to the firm stating it is in order?"—"I take it that they do."

"You say in your report that there is no 'dead-weight safety-valve;' the spring safety-valve on the reducing-valve prevents undue pressure being obtained. You are satisfied now that the arrangement was not safe?"—"Yes; but I would like to add that if there had been no choking of the pipe there would have been no explosion."

The Commissioner remarked that, according to the company's report form, there were three kinds of examination—"internal," "thorough," and "as far as practicable." They were, he thought, very qualified words.

Mr. J. C. Hinson, another inspector to the British Insurance Company, gave particulars of an examination

he had made of the kier in June, 1915, when the gauge showed 30 lb. pressure, and he called the attention of the attendant to it, remarking that either the valve or the gauge was out of order. Witness reported the condition of the gauge, and that the foreman told him that a new one was to be fitted. The safety-valve was insufficient, and the safety of the kier depended on the proper working of the reducing-valve.

Mr. H. G. Dixon, engineer-surveyor to the Board of Trade, at this point gave particulars of some series of tests he had made of the pressure-gauge, and further dealt with the question of stoppage of the valve being due to dirt carried by the steam through the reducing-valve and settling in the syphon-pipe.

This concluded the evidence, and Mr. Vaux handed in a list of questions on which he asked the judgment of the Court, after which Mr. Robson and Mr. Pickstone addressed the Court at considerable length on behalf of their clients. Mr. Pickstone pointed out, as representing Messrs. Spencer and Curedale, that monetary considerations were nothing in such a case as this. It was a most lamentable occurrence to happen to a firm after years of security, and he felt reluctant, in the face of the loss of several lives and injuries to other persons, to say anything on that point; but he submitted he was entitled to claim some consideration, as the loss of the firm had been 4000*l.*, towards which they received 1000*l.* from the British Insurance Company. Further, they had also had to provide temporarily 1500*l.* or 1600*l.* towards help in the case of those killed and injured pending certain negotiations.

Mr. Vaux, on behalf of the Board of Trade, said it was quite obvious that the explosion was not an accident, but it could and ought to have been prevented. He thought it was admitted that the explosion was brought about by the kier being subjected to a very much higher pressure of steam than it was constructed to withstand. It was, he thought, proved conclusively—admitted, really—that at the time of the explosion, the dead-weight safety-valve was practically choked up, and the steam-gauge was in the same condition; the steam-gauge and reducing-valve were not working properly, and the sentinel valve was inoperative. The steam-gauge was out of order six weeks before the explosion, and the defective condition of the reducing-valve, as it was produced to the Commission, he thought conclusively showed that it must have been quite out of order a long time before the explosion.

On the eighth day of the proceedings, the presiding Commissioner gave judgment at great length and pointed out that there was no one employed at the works with technical knowledge who could overhaul the reducing-valve or the pressure-gauge. He then dealt with the reports of the insurance company and pointed out that they stated it was not part of their duty to examine the inside of the valves. The reducing-valve was looked upon apparently as an ornament and not for use by the men employed at the works. The reducing-valve was wholly ineffective, while, as to the pressure gauge and syphon-pipe, the pipe and cock were choked solid with dirt. The explosion was caused, the presiding Commissioner said, by over-pressure of steam in the kier, and that two factors contributed to the explosion:—

1. The absence of any safety-valve of sufficient area to relieve the over-pressure; and

2. The dead-weight safety-valve and the 1-in. pipe were practically choked at the time of the explosion.

The tests made by Mr. Dixon, Board of Trade surveyor, and others showed that the pressure gauge was out of order, unreliable, and therefore of no assistance whatever to the men who looked at it.

The Commissioner then dealt with and replied to several questions submitted to the Court by Mr. Vaux as to the inadequacy of the fittings, the unsatisfactory inspection which had been made of the fittings, and the fact that Messrs. Spencer and Curedale had not taken measures to ensure that the kier was worked under safe conditions.

The Court held that Messrs. Spencer and Curedale, Limited, and Mr. Spencer, the manager, were to blame for the explosion. The Commissioner thought, further, that whatever was the legal relationship between the insurance company and the owners, the latter relied on the inspectors and the reports of the company. As to Messrs. McGough, Wolstenholme and Hinson, the inspectors, they were not, any of them, in the Commissioners' judgment, to blame. As to the insurance company, and Mr. Mason, their inspector, they judged them to blame for the explosion. The company was aware that the area of the dead-weight valve was not sufficient to relieve the kier of excessive pressure, and, in the Commissioners' opinion, the diminutive size of that valve was one of the factors that contributed to the explosion. After dealing with the evidence of Mr. Mason, the Commissioner said that the Court considered that when the insurance company was informed by their inspector that the spring safety-valve on the reducing-valve prevented undue pressure they should have ascertained the diameter of the valve; but the company did not ascertain that the so-called safety-valve was only a ½-in. sentinel-valve, until after the explosion. In the Commissioners' opinion, if there had been a safety-valve, or valves of adequate area, that explosion would have been averted. The Commissioner said he wished to point out that the insurance company and their officials had given the owners and the Court every possible assistance with a view to ascertaining the true cause of the explosion, and without in any way seeking, as was so often done, to avoid liability, while they had also paid the owners' loss under the policy.

As a result of that explosion four men had, unfortunately, been killed and fifteen others more or less injured. The Act of Parliament gave that Court complete discretion over the costs of the inquiry, and in all the circumstances they thought the justice of the case would be met by ordering Mr. Mason to pay to the Board of Trade 10*l.*, the insurance company 100*l.*, and the owners 50*l.* towards the expenses of that inquiry, and the order of the Court was to that effect.

The Commissioner said that they were very grateful for the help that Messrs. Spencer and Manning had rendered at the preliminary inquiry, and that he also wished to express their thanks to the learned gentlemen who had appeared for the various parties and the Board of Trade, and also to the two Board of Trade surveyors for their assistance during the inquiry, and for the excellent plans Mr. Dixon had prepared.

In conclusion, the Commissioner expressed the great sympathy of the Court with the injured, and the relatives of those who were unfortunately killed by that explosion.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand: The office of H.M. Trade Commissioner in New Zealand has forwarded particulars in connection with a call for tenders by the Wanganui Borough Council for the supply, delivery, and erection of additional plant at the Tramway Power House, Wanganui, including pressure type gas-producer plant, gas-engine, electric generator and switch-gear. Sealed tenders, on the proper form, will be received by the Town Clerk up to noon on May 9, and should be accompanied by a cash deposit or a marked cheque for 250*l.*

Australia: The Sydney office of H.M. Trade Commissioner in Australia has forwarded a copy of the specification and tender form in connection with a call for tenders by the New South Wales Government railways and tramways, as follows:—Sealed tenders, on the proper forms, will be received up to noon on April 26, by the Chief Commissioner for Railways and Tramways, Phillip-street, Sydney, N.S.W., for the supply and delivery at the Ultimo Power House, N.S.W., of high-pressure steam-valves (Specification No. 475). The Commercial Intelligence Branch is in receipt of an official statement giving details of items authorised by the South Australian Public Purposes Loan Bill, 1915, which provides for a total expenditure of 9,266,500*l.*; the following particulars of special interest are extracted therefrom:—

	£
Railways:	
Rolling-stock, locomotives, machinery and appliances for locomotive workshops, accommodation, line alterations, &c.	1,584,700
Railway construction	1,962,000
Harbours:	
Deepening and improvement of harbours at Port Adelaide, Port Pirie, and at outports	272,000
Murray River improvements ...	500,000
Water-Supply Works in districts of Adelaide, Barossa, Country, Beetaloo, Bundaleer, Barossa, Millbrook, Warren, and Pekina Creek	1,465,000
Drainage works in south-eastern district	300,000
Adelaide sewers	200,000
Jetties and lighthouses	42,000
Buildings:	
Erection of school-houses	140,000
Police barracks...	22,000
Explosives magazines...	2,000
Produce stores	20,000
The Magill Home	52,000
Roads	173,000
Miscellaneous works:	
Irrigation and reclamation of swamp land	300,000
Advances to settlers' and homes' funds	600,000
Sheds and tanks for settlers... ...	25,000

Spain: The British Vice-Consul at Granada reports that a new road will shortly be constructed, crossing the Sierra Nevada at an altitude of nearly 10,000 ft., and descending into the Alpujarras district, placing many villages within easy access of the capital of the Province. The Government has granted 2,000,000 pesetas (about 80,000*l.*) for this undertaking. The Société des Mines et Hauts Fourneaux has commenced work on the narrow-gauge railway to connect Motril and Orgiva. It is considered probable that when this railway is completed the tramway company at Granada will open a new tramway line between Granada and Orgiva, so bringing the port of Motril within easy reach of Granada.

Brazil: The *Diario Official*, Rio de Janeiro, publishes a Decree (No. 11,920) approving the plans for the construction of the last section of the Lages-Macáu branch of the Rio Grande do Norte Central Railway. The length of this section is approximately 51½ km. (about 32 miles), and the estimated cost of the undertaking is 2,667,317 milreis (about 133,300*l.* at current rate of exchange).

Argentina: The *Boletin Oficial*, Buenos Aires, notifies that tenders are invited by the Irrigation Department of the Argentine Ministry of Public Works for the supply of a metal bridge, 125 metres in length, in nine sections. Tenders will be received up to 3.30 p.m. on April 3 at the Dirección General de Irrigación (Oficina de Compras), Calle Belgrano, 124, Buenos Aires. Local representation is necessary.

Chile: The *Diario Oficial*, Santiago, publishes a Decree, dated November 17, granting to Messrs. Gibbs and Co. permission to construct a wharf at the port of Mejillones for the loading and unloading of nitrate and coal. Within six months from the date of the Decree the concessionaires must present for approval to the Government plans and estimates relative to the projected works. Constructional work must be commenced within six months of the approval of the plans and completed within a period of two years. The *Diario* also contains a Decree, dated November 19, conceding to Don Horacio Urrutia Gundian permission to establish a telephone system connecting Combarbalá, to the north, with Illapel, Los Vilos, Salamanca and Petorca, in the south. Work must be commenced within a period of eight months from the date of the Decree. A further Decree, dated November 26, was published in the *Diario*, granting a concession to Eduardo Germain for the construction and working, for a period of sixty years, of a railway between Palo de Luma and the Los Hulmos Estate, in the Province of Valdivia. The gauge of this line will be 60 cm., and its length about 14 km. (8¾ miles). Definite plans and estimates of construction are to be submitted for the approval of the Government within a period of ten months from the date of the Decree. Construction work must be commenced within six months, and completed within two years, from the date of the approval of the plans. The *Diario* publishes a law authorising the Chilean Government to contract loans with banks in Santiago up to the amount of 1,500,000 pesos (about 51,500*l.*) for the execution of street-paving works in that city. The *Diario* further published a Decree, dated December 21, authorising Señores Federico Gordtzen and Rafael García Huidobro to utilise the waters of the Rio Coquimbo, at the rate of 7500 litres per second, for irrigation purposes in the Department of Serena. The concessionaires must present plans of the necessary canal, &c., works within a year from the date of the Decree.

GERMAN IRON EXPORT TO SCANDINAVIA.—As soon as it became known that the prices of German iron exported to the Scandinavian countries would have to be raised, the three Scandinavian countries took joint action. An application has been forwarded to the German Steel Union, which controls the export to the Scandinavian countries, urging the Steel Union not to use the new regulations as a means of cancelling or in other directions failing to carry out the current contracts. In the meantime the Danish engineering firms advertise that they have been compelled to raise their prices.

THE CUMBERLAND PROCESS OF PREVENTING CORROSION.—A paper recently read by Mr. J. F. Peter, at a meeting of the Institute of Marine Engineers, contains some interesting information on the Cumberland process of preventing the corrosion of boilers, condensers, and other metallic vessels and structures in contact with water or other corrosive liquids. The process has been referred to on several occasions in our columns, and is now being extensively adopted in this country, so that it will probably be familiar to most engineers. We may, however, mention that the principle upon which it depends for its action is the application of an electromotive force to overcome those produced by two dissimilar metals, or the same metal in different conditions, in contact with an electrolyte. This is accomplished by fitting one or more iron electrodes into the vessel to be protected and connecting them to the positive pole of a small dynamo, generating a continuous current at a pressure of about 8 volts. The iron electrodes are insulated from the vessel, to which the negative pole of the dynamo is electrically connected, so that a current flows from the iron electrode to the walls of the vessel while the apparatus is in use. This has the effect of confining the corrosion entirely to the iron electrodes, which are gradually eaten away, but which can be replaced at a trifling cost. The current is regulated by resistances and measured by an ammeter. In the case of boilers it has been found that the system not only prevents corrosion, but also prevents the formation of scale and removes any old-standing scale which may have been deposited before the apparatus was installed. The current necessary to afford complete protection in the case of a condenser is about 1 ampere for each 500 sq. ft. of cooling surface, so that a condenser with 6000 sq. ft. of surface would require a current of 12 amperes. The energy required at 8 volts would therefore be 96 watts, and the cost at ½d. per kw.-hour would be 35s. per annum, running continuously. Six cast-iron electrodes, each weighing 20 lb., would be used in such a condenser, and these would have to be renewed once a year, at a cost of about 15s. In boilers where the question of scale formation has to be considered a rather heavier current is necessary, and for ordinary marine boilers about 1 ampere is usually allowed to each 300 sq. ft. of heating surface. If corrosion only has to be guarded against, a smaller current density can be used. A case is mentioned of a vessel having twelve Yarrow boilers, each with 4125 sq. ft. of heating surface, which it was found in practice could be completely protected from corrosion, and kept quite free from scale, with a current of 5 amperes per boiler, though when installing the system it had been decided to supply 14 amperes per boiler. The electrodes in each of these boilers consisted of two 7-ft. lengths of 3 in. by ⅝ in. bar-iron fitted in the steam-drum joint below the water-level; their life will be considerably longer than two years.

CATALOGUES.

Driving-Chains.—We have received from "The Coventry" Chain Company, Limited, of Spon End, Coventry, a pamphlet giving prices and full particulars of noiseless, roller, and block chains for motor-cycles, cycles, lawn-mowers, magnetos, &c.

Ventilators.—A leaflet to hand from Messrs. Robert Boyle and Son, of 64, Holborn Viaduct, E.C., deals with the use of their well-known "air-pump" ventilators for the ventilation of kinematograph theatres. The ventilators are used to extract foul air from the roof of the building, and fresh air is admitted through numerous small openings distributed around the walls at about the level of the heads of the patrons. With this arrangement it is claimed that efficient ventilation is secured with the complete absence of draughts. It is also pointed out that the system is a natural one, which is always in operation, and that there are no moving parts to get out of order or require attention.

Asbestos Goods and Belting.—Messrs. Turner Brothers, Limited, of Rochdale, have issued a pamphlet in which are reproduced a series of full-page advertisements that have appeared in the daily Press, with a view to bringing the firm's products to the notice of merchants, agents, and others. The series was inaugurated with a fine pen-and-ink drawing by Bernard Partridge, symbolising the protection afforded by abestos against the elements, and this was followed by others relating to asbestos-cement building-sheets and roofing-tiles, and hair and balata belting. Other products of the firm include engine-packings and jointing-sheets, insulating materials for boilers and steam-pipes, asbestos goods for chemical and electrical work, for water filtration, and for many other purposes. The goods are manufactured entirely at the firm's works at Rochdale and Trafford Park.

Paints, Varnishes, &c.—Messrs. Wilkinson, Heywood, and Clark, Limited, of Caledonian Works, Poplar, E., have sent us a pamphlet giving some particulars of the various paints, enamels, varnishes, lacquers, &c., they supply to meet the requirements of Government contractors. The firm's products are used for coating shells, aeroplanes, gun-carriages and ordnance, machine-tools, scientific instruments, motor-cycles, &c., as well as in marine, electrical, and hospital work, and the pamphlet is divided into sections devoted to the respective requirements of each trade. Another pamphlet from the firm contains some valuable notes on finishing shells by painting and varnishing them, and illustrates methods by which the work can be greatly expedited. In this respect the firm claim to hold a unique position, owing to their long experience in the manufacture of shell-varnishes, and to the fact that they are themselves engaged on the manufacture of shells.

Metal-Filament Lamps.—A price-list of "Royal Ediswan" drawn-wire-filament lamps has been issued by the Edison and Swan United Electric Light Company, Limited, of Ponders End, Middlesex. In addition to the more ordinary patterns, the list includes low-voltage and fancy lamps, high-candle-power lamps, tubular and olive-shaped lamps, and a series of lamps in which the filaments are designed to deliver the maximum light in a downward direction. These lamps are made with a separate reflector of opal glass which fits closely round the upper part of the lamp, and is secured by a metal sleeve. It is pointed out that the reflectors, while concentrating most of the light vertically downwards, allow sufficient light to be emitted in other directions to give a reasonable illumination all round the lamp. Prices are also stated for half watt gas-filled lamps for which an average life of 800 to 1000 hours is claimed. We notice that these lamps are now listed for 60 to 1500 watts for use on 100 to 130-volt circuits, and for 100 to 1500 watts for 200 to 255-volt circuits. All the lamps dealt with are manufactured entirely in this country.

Mine Gas-Detector.—A leaflet to hand from the General Electric Company, Limited, of 67, Queen Victoria-street, E.C., relates to a portable mine gas-detector manufactured by them under Philip and Steele's patent. The apparatus, which is all contained in a strong box, weighing about 13 lb., shows by the movement of a pointer over a scale the percentage of fire-damp present in any part of a mine, a determination taking less than 15 seconds and being accurate to within 0.03 per cent. Two forms are made: one with a scale graduated from 0 to 3 per cent. of fire-damp, and designed for use in collieries using safety-lamps; and the other graduated up to 1.5 per cent., and specially intended for use in collieries in which naked lights are permitted. The latter form has been designed to give very accurate readings between 0 and 1 per cent. of gas, but both can be used with perfect safety in the most fiery mines. With these detectors a sample of air can easily be taken from a crevice, or other more or less inaccessible point, the air being drawn through a flexible tube by means of a hand-pump. The leaflet gives no explanation of the principle upon which the apparatus depends for its action.

Turbine-Driven Centrifugal Pumps.—Messrs. Willans and Robinson, Limited, of Victoria Works, Rugby, have sent us a pamphlet relating to turbine-driven centrifugal pumps specially intended for marine work, such as bilge-pumping, ballast-pumping, or salvage, but capable of being used for many purposes on land. The sets comprise a single-wheel impulse turbine direct coupled to a high-speed pump, the turbine disc and pump-impeller overhanging at opposite ends of a shaft supported in two long and substantial intermediate bearings. The bearings are carried in a cast-iron pedestal, to which the pump and turbine-casings are bolted, and which is itself mounted directly on the foundation block or girders carrying the weight of the set. At present two standard sizes are stocked, having normal outputs of 1600 and 2400 gallons per minute against a total manometric head of 50 ft. when running at 2000 revolutions per minute. The steam and water connections can be varied to suit almost any arrangement of piping. The pamphlet illustrates and fully describes the construction of both steam and water ends, and also gives weights and general dimensions of the standard sizes; other sizes can, however, be supplied.

Iron and Steel Works Plant and Structural Steel Work.—Messrs. Ashmore, Benson, Pease and Co., Limited, of Stockton-on-Tees, have issued a catalogue illustrating examples of their work. The first section of the catalogue includes illustrations of blast-furnaces and accessories, such as Cowper stoves, hot-blast mains, gas-mains, tar-washers, charging-hoists, &c., while the next section deals with coke-ovens and by-product recovery plant, tar-distilling plants, coke-quenching machines, and other plant for use in connection with coke-oven installations. The remainder of the catalogue is devoted to general constructional work, and shows examples of large riveted steel pipes and culverts, light bridges, cast-iron and steel tanks, steel-framed buildings, roofs, chimneys, coal-bunkers, grain-silos, pit-head gears, gas-producer plants, gas-holders, buoys, Forter valves for reversing regenerative furnaces, ingot-moulds for steel works, and vessels constructed of acid-resisting cast-iron for chemical works. The illustrations, most of which are reproduced from photographs, are only intended to give a general idea of the class of work undertaken by the firm; it has not been found possible to show examples of all their productions.

Pile-Driving Hammers.—A booklet relating to the McKiernan-Terry pile-driving hammers has come to hand from the British Steel Piling Company, of Dock House, Billiter-street, E.C. These hammers can be operated either by steam or compressed air without any alteration or adjustment, and have only two moving parts—the valve and the piston, which delivers the blow on to the pile through the medium of an anvil block. The latter forms part of the hammer and is inserted between the piston and the pile to protect the ends of the latter from damage. Driving-frames are quite unnecessary with the smaller sizes, and need not be used with the larger sizes, as the hammers can be operated when suspended from a crane or sheer-legs, the air or steam being supplied by a flexible hose. The hammers will work under water, and can also be inverted and used for extracting piles without any alteration. They are listed in seven sizes, the smallest of which has a piston weighing 21 lb., and giving 500 blows per minute, while in the largest the piston weighs 1250 lb. and delivers 200 blows per minute. The larger sizes may be used to drive the heaviest steel-sheet piling or medium lengths of the heaviest ferro-concrete or timber piles.

Drawing and Surveying Instruments and Materials.—Messrs. A. G. Thornton, Limited, of Paragon Works, King-street West, Manchester, have recently issued a new edition of their catalogue of drawing and surveying instruments and drawing-office supplies. This catalogue, which is exceptionally complete, contains nearly 450 pages and over 1000 illustrations. It includes sections dealing with all kinds of drawing instruments, both loose and in cases; surveying instruments, such as theodolites, tacheometers, levels and accessories, chains, tapes, planimeters, clinometers, &c.; drawing-office requisites, such as drawing-tables, filing-cabinets, drawing-boards, T-squares, set-squares, and curves; and photo-printing machines and sundries of all descriptions. Other sections are devoted to drawing-papers, tracing-papers and cloths, sectional papers, &c.; slide-rules, pocket-rules and scales; inks and colours, pencils and rubbers, stencil-plates, &c.; sketch-books, level and field books, and books and pads of sectional paper. The firm have also issued a pocket-catalogue containing a selection of instruments and materials suitable for draughtsmen and students. Surveying instruments, which occupy approximately one-third of the larger catalogue, are not included in the pocket edition.

Earth-Grading Machines and Dumping-Wagons.—A catalogue to hand from the Western Wheeled Scraper Company, of Aurora, Illinois, U.S.A., gives some particulars of their earth-grading machines fitted with spoil-elevators, and illustrates the application of these machines to the construction of roads, railways, embankments, ditches, canals, &c. The machines consist of a special form of plough attached to a strong frame built up of rolled-steel sections, and mounted on four steel wheels. The earth dug up by the plough is delivered on to a band-conveyor placed at right angles to the length of the machine, and is either dropped into a wagon travelling beside the machine or allowed to fall on to the ground again, according to the nature of the work in hand. The machines may be drawn by a team of horses or by any form of mechanical haulage. Special forms of dumping-wagons for transporting the material excavated by the grading-machines, or by any other means, are made by the company, and particulars of these will be found in this catalogue. Another catalogue received from this company, and printed in French, gives particulars of railway dumping-cars, ploughs, earth-spreaders, road-scraping machines, and rock-breakers, as well as of the grading-machines and dumping-wagons above referred to.

Speed-Reduction Gears.—Particulars of speed-reduction gears for use with steam-turbines, electric motors, and other high-speed machinery, have reached us from the Turbo Gear Company, of Industrial Building, Baltimore, Md., U.S.A. These gears, which are of the epicyclic type and have machine-cut double-helical teeth, comprise a pinion gearing with three planet wheels, which all engage with, and are surrounded by, an internally-geared ring. The pinion is of chrome-vanadium steel, and is cut integrally with the high-speed shaft, and the planet wheels, which are of manganese-bronze, are mounted on steel shafts keyed to a steel casting, which forms the low-speed member, and carries the low-speed shaft. The low-speed shaft is in axial alignment with the high-speed shaft, a feature which facilitates erection, and gives the gear a symmetrical appearance. The low-speed member is mounted on two ball-bearings supported by a cast-iron housing, which totally encloses the whole of the gearing, and the high-speed shaft and pinion is also supported directly by the housing, independently of the low-speed member; the housing, it should be mentioned, is split horizontally to give easy access to the gearing. The bearings of the high-speed shaft have forced-feed lubrication, and are also provided with ring-oilers to prevent damage in case of failure of the forced-lubrication system. Oil for the gears is pumped through a passage in the high-speed shaft to radial holes in the pinion, and delivered from them in a continuous stream on to the teeth of the gears. The bearings for the planet wheels are lubricated with the superfluous oil from the high-speed bearings, this oil being collected by a centrifugal ring and delivered through passages in the shafts carrying the wheels. The oil from the gears and bearings drains back to a reservoir in the base of the housing, and is there strained and cooled before returning to the oil-pump. It is claimed that this system of lubrication gives much better results than running the gears in a bath of oil. The gears are listed with speed ratios ranging in small steps from 4.88 : 1 to 16 : 1, and for speeds ranging from 1000 to 6000 revolutions per minute of the high-speed shaft. Their efficiency is guaranteed by the makers to be not less than 95 per cent. at full load, and it is claimed that efficiencies of 98 per cent. and 99 per cent. have been recorded on tests. Mr. F. A. Yerbury, of Broadway-court, Westminster, S.W., is the sole agent for the gears in Great Britain and the Colonies.

INDIAN RAILWAY IMPORTS.—The value of the imports of railway plant and rolling-stock into British India in the ten years ended with 1914, inclusive, was as annexed:—

Year.	Value.	Year.	Value.
	£		£
1905	939,772	1910	3,627,064
1906	1,081,745	1911	2,830,221
1907	2,772,260	1912	2,967,970
1908	4,800,550	1913	4,308,598
1909	4,946,600	1914	6,689,794

It will be observed that the aggregate value for the first five years was 14,540,927*l.*; and for the second half of the decade 20,313,647*l.*, so that Indian railways have been increasingly valuable sources of employment to British industrials. To the 6,689,794*l.* representing the value of the imports in 1914 the United Kingdom contributed 6,219,223*l.*, and Australia 194,820*l.*, the final balance of 275,751*l.* being represented by deliveries from other countries.

MACHINERY TRADE OF NEW ZEALAND IN 1914.—Mr. W. G. Wickham, late H.M. Trade Commissioner for New Zealand, now H.M. Trade Commissioner for South Africa, has furnished to the *Board of Trade Journal* particulars relative to imports of machinery into New Zealand in 1914:—Of the total value of the imports of machinery into New Zealand in 1914, about one-half paid duty under the preferential tariff. The electrical machinery and cables imported are almost entirely for lighting, telegraph, and telephone purposes. Of the imports of internal-combustion engines, more than half are for motor-cycles and motor-boats. Taking the items which come under the preferential tariff, such competition as there was in steam-engines was American. Most of this is accounted for under the heading "locomotives." The heading "internal-combustion engines" has been divided, and shows separately the engines for motor-cycles, which were almost entirely British. The other group included all the stationary engines, as well as those for motor-boats. The latter were almost all supplied from America. Apparently United Kingdom manufacturers have hitherto not been disposed to take up either the manufacture or the sale of these motor-boat engines very seriously, when they had the assistance of a preferential duty of 20 per cent. against American engines; and, as the preference has now been reduced to 10 per cent., it seems unlikely that they will do better in future. In the groups of machinery where competition is open, and no preferential duties apply, the United Kingdom made a poor show in 1914. Office requisites—*i.e.*, typewriters, calculating-machines, and cash-registers—were all American, with the exception of 3000*l.* worth of typewriters. As regards knitting and sewing-machines, Germany was the only competitor with the United Kingdom with respect to the former. In sewing-machines, however, the United States did three-fourths of the trade, and the other quarter was divided equally between the United Kingdom and Germany. A parallel case is to be found in type-setting and casting-machines, which are specifically exempted from the preferential duty to which all other printing machinery is liable. As a result, though the whole of this machinery might easily be supplied from British works, in 1914 only 3000*l.* worth came from the United Kingdom, as against 13,000*l.* worth from America. Telephones in the past provided a similar instance of goods being consistently supplied to the New Zealand market from foreign works when they might easily have been supplied from works in the United Kingdom. Of machine-tools the United Kingdom supplied nearly two-thirds; the remainder was shared by the United States and Germany, the latter country being credited with 5 per cent.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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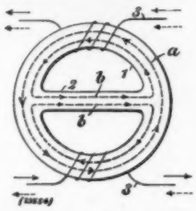
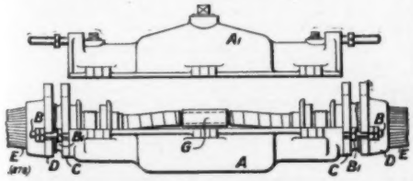
ELECTRICAL APPARATUS.

22,554/14. British Insulated and Holsby Cables, Limited, Prescot, W. P. Fuller, Chester, and H. H. Harrison, London. Duplex Telephony. [8 *Figs.*] November 14, 1914.—This invention relates to an improvement in the art of duplex telephony, and contemplates an improved construction of Pupin coil. It is understood that when Pupin coils are employed for the simultaneous loading of phantom and physical circuits the phantom circuit-loading coils must be non-inductive to the currents from the physical circuits, while the physical circuit-loading coils must be non-inductive to the phantom currents, while each set of coils must be fully inductive to the circuit to which it is applied for loading purposes. It is also understood that the system of winding adopted must be such as to secure a balanced action, as otherwise, with the ring type of core used, poles will be produced, giving rise to stray fields, which set up eddy-currents and lead to loss of energy by increasing the damping of the circuit. In accordance with the present invention, the simultaneous loading of the phantom circuit with its associated side circuits is accomplished by the use at the loading-



points of a coil common to the physical and the phantom circuits without the production of a stray field. Moreover, by the use of a coil made in accordance with this invention, the field produced by the phantom circuits can be used to load such circuits, and, moreover, such loading can be adjusted. The improved loading-coil illustrated consists of an annular core 1, with a diametral limb 2 traversing the core magnetically symmetrically, and a single winding 3, wound, as shown, around the core on each side of the diametral limb. Currents due to the physical circuit produce a circular flux, shown by the outer circular dotted line *a*, while a flux of the form shown by the inner dotted lines *b*, *b* is produced by the phantom currents. It will be seen that with the construction herein shown it is possible to load the physical and phantom circuits simultaneously by means of a single core without the production of a stray or leakage field. It will be appreciated that the shape of the core is immaterial, the important feature being the traversing of the core by a limb to form magnetically symmetrical halves. By varying the cross-section of the iron path traversed by the flux due to the phantom currents it is possible to adjust the loading to which the phantom circuits are subjected. (*Accepted November* 10, 1915.)

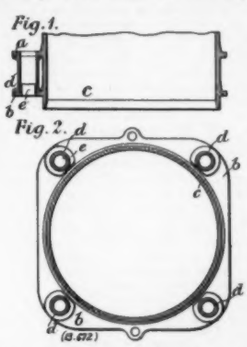
378/15. A. H. Railing and C. C. Garrard, London. Cable Joint-Boxes. [4 *Figs.*] January 9, 1915.—This invention relates to improvements in joint-boxes suitable for armoured cables, and its object is to provide convenient and efficient means for clamping the armouring of the cable to the joint-box in such manner that the armouring can be firmly clamped to the box before the top or front or upper half of the box is put on, and, if desired, before the conductor joints are made. This invention consists essentially in the provision of an armour-clamp which can be fixed rigidly to the lower half of the joint-box, quite independently of the upper half thereof, whereby the cable and its armouring can be completely supported before any joint is made. In carrying the invention into effect, the lower portion A of the box underneath each cable inlet is provided with means, such as two or more bolts or studs B and nuts B¹, for fixing to it the flanged armour-clamping members C, which are coned externally as shown.



A flanged internally-coned clamping member or cap D, which corresponds with the externally-coned member, is provided for each clamp, and has holes or slots for passing over the said bolts or studs B that secure the members C to the ends of the box. The armouring E of the cable F is splayed out and laid over the externally-coned member C of the clamp, and firmly held against it by means of the internally-coned member D and the clamping nuts. It will thus be seen that the armouring E of the cable is first of all rigidly clamped to the box before any joint G in the conductor is made, and before the upper half A¹ of the box is bolted to the lower half A. It is essential, according to this invention, that the cable-clamps can be rigidly fixed to the lower half of the box, independently of the upper half of the box. Thus at least two bolts, screws or studs B are used for fixing the armour clamps to the lower half of the box, and these are preferably arranged as nearly as possible across a diameter of the cable-clamp so as to ensure a firm fixing. (*Sealed.*)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

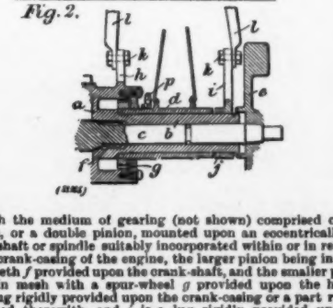
13,672/15. F. H. Royce and Rolls Royce, Limited, Derby. Internal-Combustion Engines. [2 *Figs.*] September 25, 1915.—This invention relates to an improved method of, and means for, securing steel cylinders of internal-combustion engines—particularly engines for aircraft—to the crank-case, or of securing combustion heads to such cylinders, and has for its object to keep the cylinder extremely light and to retain the advantages of a boss made integral with the cylinder and drilled to accommodate a bolt or stud, while avoiding the use of metal requisite to distribute the load over a considerable area of the cylinder wall. The present invention comprises essentially forming a pair of relatively thin flanges out of the

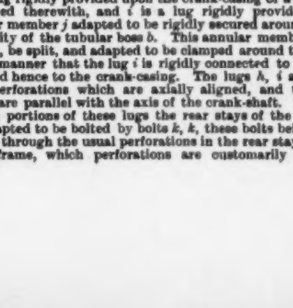


solid at a suitable distance apart and towards either or both ends of the cylinder, and fitting hollow distance-pieces between the said flanges, the securing-bolts passing through holes in the said flanges and through the hollow distance-pieces. Two flanges *a* and *b* are turned out of the solid and spaced at a suitable distance apart towards the extremity of the cylinder barrel *c*. At each point where it is decided to place a securing-bolt a hollow distance-piece *d* is inserted a tight fit between the two flanges, and is located in position by a ferrule or sleeve *e*. When the securing-bolt is tightened up it will be observed that the arrangement provides adequate support for the flanges, and at the same time is capable of distributing the load over a greater portion of the circumference of the cylinder. (*Sealed.*)

MOTOR ROAD VEHICLES.

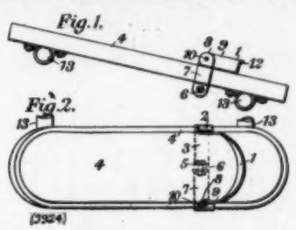
22,165/14. Auto Wheels, Limited, and A. M. Pooley, London. Motor Attachments for Cycles. [2 *Figs.*] Nov. 7, 1914.—This invention comprises a motor-driven road-wheel adapted to be substituted for the rear road-wheel of an ordinary standard pedal bicycle without necessitating any brazing operation, and without necessitating any alteration in the part of the bicycle retained, and in which both the driving-motor and a gear, which is incorporated between such motor and the motor-driven road-wheel are located at the side of the main plane of the wheel. *a* is the crank-casing of the engine from which the tubular boss *b* projects, and in the interior of which tubular boss the crank-shaft *c* is disposed. Around the tubular boss *b* the hub *d* of the rear road-wheel is disposed, which hub *d* may, if desired, be mounted in relation to the tubular boss *b* with intermediate ball-bearings, or it may have a plane bearing upon the boss *b*, as shown. A fly-wheel *e* is secured to the outer extremity of the crank-shaft *c*, and such crank-shaft *c* is in gear with the hub *d*

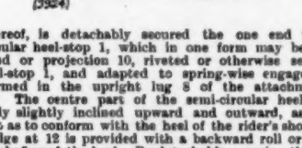




through the medium of gearing (not shown) comprised of two pinions, or a double pinion, mounted upon an eccentrically-disposed shaft or spindle suitably incorporated within or in relation to the crank-casing of the engine, the larger pinion being in mesh with teeth *f* provided upon the crank-shaft, and the smaller pinion being in mesh with a spur-wheel *g* provided upon the hub *d*. A is a lug rigidly provided upon the crank-casing or a part rigidly combined therewith, and *i* is a lug rigidly provided upon an annular member *j* adapted to be rigidly secured around the outer extremity of the tubular boss *b*. This annular member *j* may, if desired, be split, and adapted to be clamped around the boss *b* in such a manner that the lug *i* is rigidly connected to the tubular boss and hence to the crank-casing. The lugs A, *i* are provided with perforations which are axially aligned, and the axes of which are parallel with the axis of the crank-shaft. To the perforated portions of these lugs the rear stays of the cycle frame are adapted to be bolted by bolts *k*, *k*, these bolts being adapted to pass through the usual perforations in the rear stays *l*, *l* of the cycle frame, which perforations are customarily adapted to accommodate the rear wheel spindle. The arm or member *m* extending forwardly from the crank-case *a*, and which may be hollow and may constitute a silencing-chamber for the engine, is advantageously furnished with a lug, fixture, or the like, *n*, by which it may be clipped to a side stay of the cycle frame at a position *o* in advance of the points of connection previously described, this having the effect of preventing movement of the engine unit in relation to the cycle frame. The engine, or the major part thereof, occupies a position on the outer side of the frame stays of the cycle, and the fly-wheel *e*, which may occur on the other side of the cycle frame, also occupies a position on the outer side of the cycle-frame stays. A free-wheel sprocket *p* may suitably be incorporated upon or in connection with the motor-driven road-wheel hub *d*, and may be in gear by the medium of the usual pedal-chain with the existing chain-wheel and pedals, so that the rider can start or assist the motor. (*Sealed.*)

3924/15. The Birmingham Small Arms Company, Limited, and C. A. Hyde, Birmingham. Motor-Cycles. [5 *Figs.*] March 12, 1915.—This invention relates to a new or improved heel-stop for footboards of motor-cycles, and has for its object the employment of a stop or support for the heel of the foot of the rider, which is capable of adjustment to any desired position on the footboard to suit or meet the varying requirements of different riders. A heel-stop for the footboards of motor-cycles, according to this invention, comprises a semi-circular or curved plate adapted to be adjustably mounted on the footboard by means of a two-part attachment-clip, one end of the plate being secured to one part of the attachment-clip, whilst the other end is adapted to detachably engage with the other part of the attachment-clip. A semi-circular hoop 1 is provided, preferably of springy strip metal, one end of which is riveted or otherwise secured to an upright lug 2, formed on a clip-attachment piece or side-plate 3, which embraces the edge of the footboard 4 and extends along the underside to near the centre thereof, its inner end 5 being bent downwards at right angles, thus forming a depending lug or projection in which is provided a hole to receive a clamping-bolt 6. A second similar clip-attachment piece or side-plate 7 is also provided, which is adapted to fit the opposite side of the footboard 4, and to the upright lug 8, on the upper





side thereof, is detachably secured the one end 9 of the semi-circular heel-stop 1, which in one form may be effected by a stud or projection 10, riveted or otherwise secured to the heel-stop 1 and adapted to spring-wise engage with a hole formed in the upright lug 8 of the attachment-clip piece 7. The centre part of the semi-circular heel-stop 1 is preferably slightly inclined upward and outward, as seen in Fig. 1, so as to conform with the heel of the rider's shoe, and its upper edge at 12 is provided with a backward roll or curve to prevent chafing of the heel. By detachably securing the one end of the semi-circular heel-stop 1 to one part of the attachment-clip in the manner aforesaid it permits of the device being readily attached to or detached from the footboard 4, which latter is usually supported near its front and rear ends on arms or lugs 13, which are formed on or attached to the frame of the motor-cycle. To fix the device in position, the two-piece attachment-clip is placed on the opposite edges of the footboard 4, the stud 10 on the detachable end of the semi-circular heel-stop 1 being passed into engagement with the hole in the lug-part 8 on the side-plate 7, and the latter is then securely locked in any desired position by the clamping-bolt 6. It will be readily understood that to move or adjust the heel-stop it is only necessary to slacken the nut of the clamping-bolt 6 when the side-plates 3 and 7 are then free and can be moved to any desired position, and be there secured by again tightening the nut of the clamping-bolt. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

22,061/14. A. W. Rendell, London. Brake Compressors. [4 *Figs.*] November 5, 1914.—This invention relates to compressors, and particularly to machines of this description adapted to operate at relatively high speeds. In such compressors lubrication is usually effected by splash lubricators in the crank-case, and trouble is frequently experienced owing to the vaporisation of the oil due to the high-speed running of the apparatus and other causes. The object of the present invention is to provide certain improvements in the construction of the compressor which render it possible to dispense entirely, if desired, with such forms of lubrication, thus enabling the crank-case to be kept practically free from oil. In carrying the invention into practice, the lubrication of the cylinders themselves is preferably effected by means of air-carrying globules or small particles of lubricant in suspension. Lubricators are known wherein a portion of the air from a compressor is caused to pass through a lubricant in a casing, carrying with it particles of the lubricant in suspension, this air being afterwards drawn into the cylinder wherein the particles of lubricant ultimately become deposited on the working surfaces. According to this invention, the compressor comprises compressing-pistons driven from a common crank-shaft, the latter of which is built up of a number of elements so disposed and connected together as to permit the insertion of ball-bearings in the big ends of the connecting-rods, and also, if desired, in the small ends of the connecting-rods. The compressor is shown as comprising a pair of cylinders 1 and 2, with the cranks arranged at 180 deg., the crank-case 3 being shown as composed of two portions 4 and 5, the portion 4 being formed integral with the cylinders 1 and 2, the portion 5 being capable of being bodily removed from the portion 4, the division line being preferably at an angle of, say, 45 deg. to the plane through the axis of the cylinders, as shown in Fig. 2, in order that the lower part of the casing may remain complete with any small accumulation of matter therein when the portion 5 of the crank-case is removed to give access to the crank-shaft. The crank-shaft 6 is shown as composed of three principal portions, two shaft members 7 and 8 extending through the main bearings 9 of the crank casing, and each provided with a crank 10, 11, the latter of which are united at the centre by a double-headed cross-piece 12. The crank-shaft 6 is connected to pistons 13 and 14 by means of connecting-rods 15 and 16 respectively, both the big ends and small ends of the connecting-rods, and also the main crank-shaft bearings comprising ball-races, as will be hereinafter described. The compressor is preferably directly driven by an electric motor 17 connected to the crank-shaft 6 of the compressor through a suitable form of coupling, as shown diagrammatically at 18. The

inlet of fluid to and its discharge from the cylinders 1 and 2 of the compressor are controlled by means of suction and delivery-valve arranged within the casting 10, constituting a cover for the cylinders. The cylinder lubricator may be applied in any convenient position, but preferably communicates with the air-inlet passage leading to the cylinders, as shown in Fig. 2, the cylinder lubricator being shown at 31. The big ends of the connecting-rods are shown as comprising ball-bearings 32, which, owing to the particular construction of the crank-shaft, may be applied to the cranks from the inner ends thereof before the intermediate member consisting of the double-headed cross-piece 12 is placed in position so as to complete the crank-shaft. The double-headed cross-piece 12 may be arranged to clamp the inner member 33 of the ball-bearings 32 of each connecting-rod end against a shoulder 34 on the crank, the double-headed cross-piece 12 being securely held in position by a nut 35 on the inner end of each crank or in any

Fig. 1.

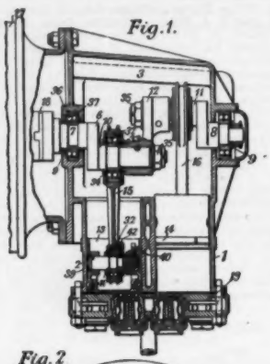
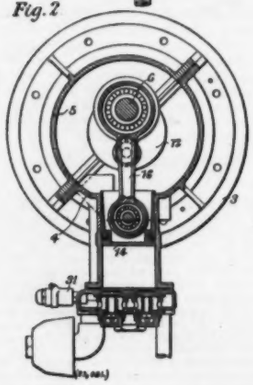


Fig. 2



other suitable manner. Ball-bearings 36 are arranged in circular housings 37 at each side of the casing carrying the crank-shaft, the housings of these ball-bearings being formed by the two parts of the crank casing, as clearly shown in Fig. 1, and ball-bearings 38 may be applied also at the small ends of the connecting-rods surrounding the pins 39 inserted through the pistons of the compressor. In a preferred construction the pins 39 are inserted from one side of the pistons 13 and 14, and locked in position by screw-sockets 40 inserted from the other side, a shoulder 41 on the pin and the end of the socket 40 serving to clamp between them the inner member 42 of the ball-bearings 38. From the above description it will be apparent that if the portion 5 of the crank casing be removed, and the crank-shaft itself be uncoupled from its driving motor, the whole crank-shaft can be taken out bodily, carrying with it its ball-bearings and also the connecting-rods and compressor pistons, it being, of course, possible to insert these parts again as a single unit. (*Sealed.*)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

22,360/14. Cockburns, Limited, D. Cockburn and D. MacNicoll, Glasgow. Valve-Operating Mechanism. [2 *Figs.*] November 21, 1914.—This invention relates to mechanism for operating valves such as described in the Specification No. 2090, of 1912. The object of the present invention is

Fig. 1.

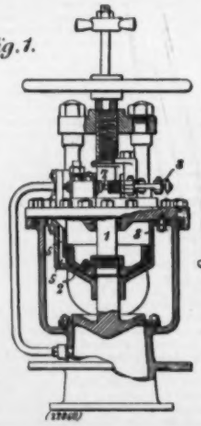


Fig. 2.

the provision of means for closing automatically the main valve when a predetermined engine speed is exceeded, such excess occurring, for instance, in the event of fracture of a transmission shaft. Hitherto it has been proposed to provide means for opening and closing throttle-valves and the like by governor-actuated gear, such means acting through the intermediary of pilot-valves to control the movement of the main valve-spindle. The present invention, which is designed only to close the main valve in emergency, consists in the provision of means, including a trip, and operable on actuation of a governor, for opening the exhaust pilot-valve, whereby steam is exhausted from the side of the main valve-piston adjacent to the valve proper, and the valve is constrained to close. 1 denotes the main valve-spindle, 2 the piston, 3 the cylinder accommodating the piston 2, 4 the inlet port to the cylinder, and 5 the outlet port; 6, 7 denote the valves for controlling the passage of fluid through the ports 4 and 5 respectively. It will be appreciated that concomitant operation of the inlet-valve 6 and exhaust-valve 7 will be accompanied by a movement of the piston 2 in the cylinder 3 and by a corresponding closing movement of the main valve. 8 denotes the member for controlling the operation of the main valve closure-control valve, the said member being preferably constituted by a lever fulcrumed at 9 on the valve casing. The member 8 is arranged to engage the underside of a nut or collar 10 fitted to the exhaust-valve spindle, so as, when rocked on its fulcrum, to impart opening movement to the exhaust-valve. The member is also connected to the main control-lever 11 by means of a link 12 to ensure that the inlet-valve 6 shall be maintained in an open position during the emergency operation of the exhaust-valve 7, the link being connected to the lever 11 by a pin-and-slot connection permitting sufficient lost motion to allow of normal operation of the lever 11. The member 8 is urged by a load constituted, for example, by a spring 13, the load acting to rock the member 8, and, in effect, to impart closing movement to the closure-control valve. The member is normally sustained against the rocking movement by a trip 14 pivoted on the valve casing, the said trip having a suitable connection with the usual governor, and adapted, when operated by the governor on excess of a predetermined engine speed, to permit operation of the closure-control valve. (*Sealed.*)

MISCELLANEOUS.

23,072/14. The British Thomson-Houston Company, Limited, London, and H. C. Wheat, Rugby. Illumination of Surfaces. [5 *Figs.*] November 25, 1914.—The invention relates to the illumination of surfaces, such as pictures, advertisement posters, transparent signs, show-cases, shop windows and the like, and has for its object to provide an arrangement which will give, when desired, substantially uniform illumination over the whole of the surface or concentrate the light at a particular place. The usual arrangement for uniformly illuminating a surface consists of an incandescent electric lamp of tubular form backed with a reflector of the trough type which is located at one side of the surface to be illuminated, so that a strong beam of light is directed at an angle to the surface towards the extreme edge of the surface opposite to the lamp. In order to obtain a balance between the normal rays on the near half of the surface and the oblique rays on the far half of the surface to give uniform illumination, the lamp must be located at some distance from the surface. The above arrangement is open to the objection that a considerable amount of light directed beyond the extreme opposite edge of the surface is wasted. The lamp being some distance from the surface, the containing-box or casing projects further than may be desirable. There is also more illumination than is necessary on the lamp side of the surface. This inven-

Fig. 1.

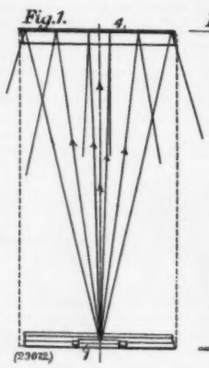


Fig. 2.

Fig. 3.

tion consists in locating the lamp with its reflector close against the surface and projecting the reflected rays substantially parallel to the surface on to a mirror at the extreme opposite side which is inclined at an angle rather less than 90 deg. to the illuminated surface. By means of this arrangement the near portion of the surface is illuminated by direct rays from the lamp, whilst the indirect rays projected by the reflector on to the mirror are again reflected on to the distant portion of the surface. In this way the surface may be illuminated by transmitted or reflected light, and in neither case is the back or front of the surface respectively covered or obstructed by a reflector. The lamp 1 is of the well-known double-ended tubular type of electric incandescent lamp, and is here shown at the bottom edge of the illuminated area, though it may also be located at the top or one of the sides. The lamp is mounted in a trough-shaped reflector 2, the cross-section of which is shown enlarged in Fig. 3. It consists of a casing 3 of sheet metal, and the reflector 2 itself may be silvered glass or glass with prismatic corrugations running at right angles to the axis of the lamp. In the latter case light rays will also be projected by the reflector obliquely towards each side of the poster. On the opposite side of the poster, in the case shown the top edge, the mirror 4 is mounted. This is a plain sheet of silvered glass or other reflecting surface—for example, glass with prismatic corrugations. The direction of the rays of light is shown by the arrows on the drawing. (*Sealed.*)

9390/15. G. A. Mower and Sturtevant Engineering Company, Limited, London. Air-Filters. [4 *Figs.*] June 26, 1915.—This invention relates to improvements in and connected with air-filters, and has reference to air-filters of that general character where the air is filtered in its passage through collapsible bags, which are shaken from time to time. According to this invention, an air-filter comprises filter-bags and means whereby the said bags are periodically caused to collapse from both ends, and are then released so that they extend again and come to a sudden stop, a shaking "flick" thus being imparted to the bags. 1 designates the filter-body or casing, which is in communication with a suction-chamber 2 at the top and a dust-collecting hopper 3 at the bottom, as will be readily understood by those conversant with this general type of apparatus. It will be appreciated that the suction-chamber will be in communication with a fan, blower, or other device adapted to create the necessary vacuum or partial vacuum. In such positions in the casing 1 as will ensure the dust-laden air passing through them, collapsible filters 4 are arranged, the casing being divided into a number of chambers 5, in each of which a series of the filter-bags 4 are located. These filter-bags 4 are carried between upper and lower frames 6 and 7 respectively, to which they are attached in any suitable manner, such, for instance, as by means of spigots 8. Beneath the lower frames 7 bellows-like members 9 form continuations of the filter-bags. The frames 6 and 7 carrying the filter-bags 4 are suspended from the roof of the casing 1 by means of flexible connections 10, which pass around the pulleys 11, the arrangement being such that the weight of the lower frames 7 overbalances the weight of the upper frames 6, so that the filter-bags 4 are normally stretched taut. It is necessary that the filter-bags be automatically shaken from time to time without interfering with the operations of the filter as a whole, and for this reason provision is made whereby the filter-bags in each section

Fig. 1.

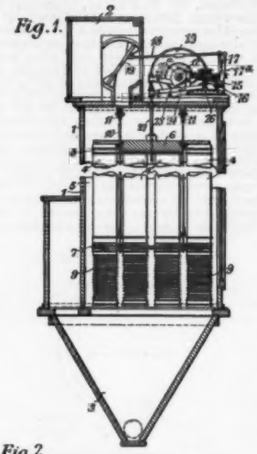
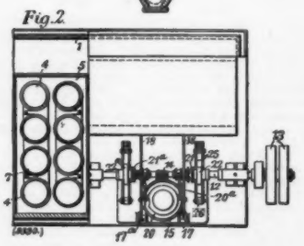


Fig. 2.



are shaken successively while all the other sections are effectively operating. This is accomplished by means of mechanism which periodically shuts off a filter section from the vacuum-chamber and opens it to the atmosphere, and then causes the depression of the upper frame 6 of the section being cleaned with a corresponding rising up of the lower frame 7. It will be clear that in this way the upper and lower frames approach each other, and mechanism is provided for ensuring a sudden release, so that the lower frame falls and pulls the upper frame up again, so that the bags suddenly tauten, and a distinct "flick" is imparted to the bags, which results in a very effective shaking. The mechanisms for effecting these movements are all of similar construction, and are arranged over each pair of filter-sections, and actuated by a common shaft 12 driven by a belt co-operating with the pulleys 13, and thus, by means of the worm 14, all the worm-wheels 15 are continuously driven. Beneath the worm-wheel 15 there is a peripheral cam 16, which serves to operate the valve mechanism of two filter-sections. This cam 16 co-operates with rollers on the ends of bell-crank levers 17 and 17a, which it operates alternately. Thus each bell-crank lever is rocked periodically, and periodically actuates its connecting-rod 18 to cause its valve 19 to cut off the filter-section it controls from the vacuum-chamber 2, and open it to the atmosphere. This position is shown in Fig. 1. Upon the upper side of the worm-wheel 15 there is a cam-plate 20, which serves to control two sets of shaking mechanism—that is to say, it operates to throw in alternately clutches 21 and 21a to clutch up the "shaking" cams 22 and 22a respectively. Each of the "shaking" cams has a rise 23, which co-operates with a block 24 fixed between the parallel bars 25, which form the "shaking" lever. This "shaking" lever 25 is pivoted at one end as at 26, and its other end engages the upper end of a rod 27, which slides through a bush in the roof of the casing 1, and is connected at its other end to the upper frame 6 carrying the filter-bags 4. It follows that in its rotation the cam 22 depresses the lever 25, and forces the upper frame 6 down a distance dependent on the shape of the cam 22, and it will be seen that if the upper frame 6 is depressed, the lower frame 7 will rise a similar distance, and the total effective collapse of the bags will be double this distance. Immediately the rise 23 of the cam 22 passes free of the block 24 carried by the lever 25, the lower heavier frame 7 will immediately drop, and its rapid travel be brought to a sudden conclusion, thus shaking one set of the filter-bags 4. After a sufficient number of "shakes" has been imparted to the bags in one section, the clutch-control arm 20a will operate to declutch the "shaking" cam 22, and the arm 18 will throw over the valve 19, to open again the filter section which has been cleaned to the vacuum-chamber, and close it to the atmosphere. At or about this time another one of the cams 20 associated with another unit of mechanism operating in connection with another of the filter sections will have reached the position where it brings into operation the shaking mechanism, and simultaneously the fresh section to be cleaned will be cut off from the vacuum and opened to the atmosphere in the manner before described. (*Sealed.*)